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ENGINEERING:

An Illustrated Weekly Journal.

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City of Cardiff Education COMMITTEE.

THE TECHNICAL COLLEGE.
Principal: CHARLES COLES, B.Sc. (Lond.).
DEPARTMENT OF ENGINEERING.
Head of Department: A. W. LOVERIDGE, B.Sc. (Eng.), A.R.C.Sc.
SESSION 1923-24.
(Commencing on Tuesday, 2nd October, 1923).

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JOHN J. JACKSON, Director of Education, City Hall, Cardiff. B 386

University of Birmingham.

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Founded 1872.
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The new Course will commence on September 12th. B 461

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This SCHOLARSHIP of the annual value of £50 will be OFFERED for COMPETITION at an examination to be held on the 10th September, 1923, and following days. Candidates must be qualified to pursue a Degree Course in the University of Wales, and the successful candidate will be required to pursue the Degree Course in Metallurgy at the University College of Swansea. The Scholarship is tenable for three years. Further particulars may be obtained from the undersigned,
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Swansea. B 447

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SESSION 1923-24.
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The TECHNICAL LABORATORY COURSES commence SEPTEMBER 25th, 1923.
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B 444

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CONSTRUCTION OF BRIDGE FOR COUNTRY ROADS BOARD, VICTORIA.

Tenders, Addressed to

The AGENT-GENERAL, and endorsed "Tender for Barwon River Bridge," will be received at this Office until TWELVE o'clock Noon on Wednesday, 24th October next, for the ERECTION of a BRIDGE over the Barwon River at Geelong, Victoria, consisting of 417 lin. ft. of deck plate girder bridge, with concrete deck, 1200 lin. ft. of approaches and 16,000 cubic yards of river excavation.
Plans and Specifications may be inspected at this Office. The lowest or any Tender not necessarily accepted. Preliminary deposit £500. B 395

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.
The Directors are prepared to receive

Tenders for :—

67 FEET CARRIAGE UNDERFRAMES (WITHOUT WHEELS AND AXLES).
Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after Monday, 27th August, 1923.
A fee of £1 1s. will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON on Monday, 10th September, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
R. C. VOLKERS,
Secretary. B 462

THE WATCHET URBAN DISTRICT COUNCIL is prepared to receive

Tenders for the Construction

of certain WORKS, including a Concrete Quay, Sheeting and Bulkhead Walls, etc., for the Improvement of the Harbour at Watchet, Somerset.
The Form of Tender, Terms and Conditions of Contract, Specification, Bill of Quantities, and Drawings may be obtained from the office of the undersigned. The charge for these will be One Guinea, which is non-returnable.
Sealed Tenders, endorsed "Watchet Harbour Improvement," must be delivered to this Office on or before Monday, the 24th September, 1923.
The Council do not bind themselves to accept the lowest or any Tender.
FRANK RISDON, Clerk.
Office of the Urban District Council, Watchet, Taunton, Somerset. B 438

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.
The Directors are prepared to receive

Tenders for :—

(1) SPRING STEEL.
(2) MILD STEEL BARS, PLATES, SHEETS AND SECTIONS.
Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after Friday, 24th August, 1923.
A fee of £1 1s. will be charged for each Specification, which is NOT returnable.
Tenders must be submitted not later than NOON on Tuesday, 4th September, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
R. C. VOLKERS,
Secretary. B 466

THE SOUTH INDIAN RAILWAY COMPANY LIMITED,
are prepared to receive

Tenders for the Supply of :—

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2. Yorkshire Iron.
3. Solid Drawn Steel Boiler Tubes.
4. Galvanised Corrugated Sheets, etc.
5. Mild Steel Bars, Sections, etc., for Miscellaneous purposes.
6. Copper Tubes, Brass Sheets, etc.
7. Spring Steel.
8. Saws.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tenders for the Steel Brake Vans and Wagons" (or as the case may be), must be left with the undersigned not later than 12 Noon on Friday, the 28th September, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of:—

£1	for each copy of	Specification			No. 1.
10/-	"	"	"	"	Nos. 2, 3, 4, & 5.
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2/6	"	"	"	"	No. 7 & 8.

Copies of the Drawings may be obtained at the offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.
A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1.
28th August, 1923. B 492

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Tuesday, 18th September,

Tenders for the Supply of :—

1. STEEL MATERIALS.
2. WHEELS and AXLES FOR CARRIAGES and WAGONS.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 20s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W. 1.
28th August, 1923. B 491

UNION INFIRMARY, STOTT LANE, WHASTE.

THE SALFORD BOARD OF GUARDIANS invite

Tenders for Heating and Hot

Water SERVICE APPARATUS, including Calorifiers, Pumps, Mains, Radiators and the like, for the above Infirmary and Nurses Home Extension.
Drawings of the Plant may be inspected at the Offices of the Engineer, Mr. T. ROLAND WOLLASTON, M.I.M.E., Lord's Chambers, 36, Corporation Street, Manchester, on or after Monday, August 27th, between the hours of Ten a.m. and Four p.m. Specification, Form of Tender and Conditions of Contract may be obtained from the undersigned on receipt of written application enclosing cheque value Two Guineas, which sum will be refunded on due receipt of *bona fide* Tender.
The Board do not bind themselves to accept the lowest or any Tender. The selected Contractor will be required to subscribe to the conditions as regards employment of labour, etc., as set forth in the Board's Regulations.
Sealed Tenders endorsed "Engineering Section 2," must be delivered at my Offices not later than Ten a.m. on Saturday, September 22nd, 1923.
E. H. INCHLEY,
Clerk to the Guardians.
Poor Law Offices,
Eccles New Road, Salford.
23rd August, 1923. B 430

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An Assistant Lecturer, who

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CITY OF BRADFORD.
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Applications, with copies of testimonials, particulars of teaching and professional experience, should be addressed to Professor R. P. PHILPOT, Finsbury Technical College, Leonard Street, City Road, and should be received not later than 5th September, 1923. B 419

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A HIGH SPEED STROBOSCOPE.

THERE are many cases in which the movement of mechanism is far too rapid for the eye to follow it in detail. Hence when matters go wrong the engineer has to rely on surmise as to where and how the trouble is originating. It has long been known that by means of the stroboscope it is possible to reduce the apparent rate of motion of any cycle of operations, and we illustrate on this page an apparatus of this kind which has been developed by the British Research Association for the Woollen and Worsted Industries, Leeds, for the observation of cap spinning. It has already been applied to other spinning processes, and has possibilities of much wider application. The field of illumination

Fig. 1.

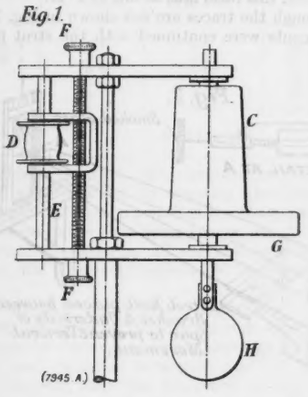


Fig. 2.

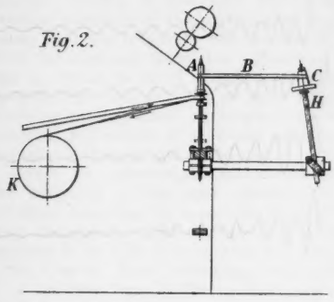
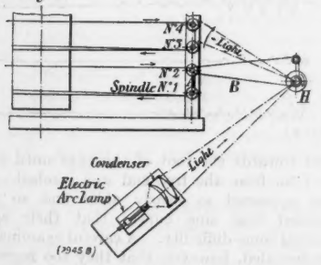


Fig. 3.



is larger than that of most stroboscopes, and the frequency is practically unlimited.

In cap spinning the yarn revolves skipping rope fashion at about 6,000 r.p.m., and in the past it has only been possible to guess the reason for certain peculiarities in the behaviour of the yarn, such as its tendency at certain times to "lick" or cling to the cap instead of flying clear as it does at other times. No existing stroboscopic apparatus seemed to be exactly suitable for the conditions. The spindles are usually arranged in a long row, and it is desirable to illuminate as many as possible at one setting of the instrument. It is also necessary that there should be free access to the spindles for "piecing," changing bobbins, &c.

The mirror type of stroboscope which has been developed illuminates objects in a horizontal plane for a considerable radius from the instrument, the distance depending only on the intensity of the light source and the darkness of the room.

A general view of the instrument is reproduced in Fig. 1, and the methods of mounting it and driving it are represented in Figs. 2 and 3, whilst Fig. 4 shows it in position as applied to an actual spinning frame. The central part is a small double-sided mirror—of silver or stainless steel, rotated about one of its diameters at half the speed of the spindle under observation. A beam of light from an arc lamp (see Fig. 3) is focussed on the mirror, and by reflection therefrom is caused to sweep through a circle, illuminating each object in its path intermittently. As already stated, the illumination and size of field in a horizontal plane, or rather in a plane at right angles to the mirror spindle, depends only on the intensity of the light source. The vertical dimension of the field can be

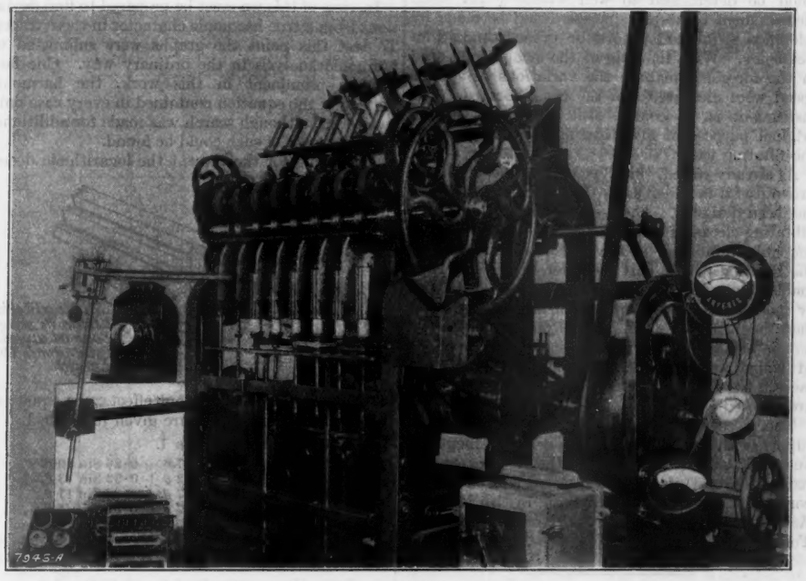
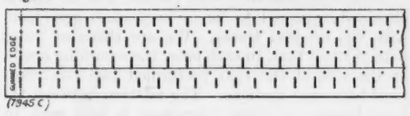


FIG. 4.

Fig. 5.



varied by adjusting the divergence of the beam, and of course at the same time the distance from the lamp to the mirror. Increasing the distance from the mirror to the object also increases the vertical dimension of the field. Generally, however, a wider field means not only less intense illumination but also less precise definition, because the ratio of the illuminated period to the period of darkness is increased, and the object under observation moves further during the illuminated interval. With careful adjustment, however, the maker's name, stamped in $\frac{5}{32}$ in. letters on a wood bobbin in rapid rotation, can be clearly read.

As an alternative to the dispersion of the beam by focussing, the mirror could, of course, be made with slightly cylindrical faces giving dispersion in a vertical but not in a horizontal plane. It is also found that a slightly imperfect silver mirror is preferable to a much more perfect glass one. The latter gives a concentrated beam with no fringe; the former, not quite plane and with imperfect polish, gives an outer zone of faint illumination besides the brilliantly illuminated central path.

In its first form the mirror was driven by a small variable speed motor to which a tachometer or counter could be permanently attached. Owing to slight irregularities in the speeds of motor and spinning frame, it was found very difficult to synchronise the mirror with the spindles, and exact synchronism was necessary if the form of the yarn was to be studied.

It was therefore found preferable to drive from the spinning frame itself by a flat cotton tape of the type already used for the spindle drives. To provide the requisite speed adjustment the driving pulley C (Fig. 1) of the mirror was made conical and the guide pulley D arranged to control the position of the driving tape of the cone. Further speed adjustment could be made by fitting different sizes of driving bobbins at A (Fig. 2). Flat cotton tapes of the type used have a sewn joint, which would have caused a marked irregularity in the running of the mirror. To prevent this, a flywheel G (Fig. 1) is provided on the mirror spindle. The short tape is run slack, just tight enough to overcome the friction of the mirror. Whenever the effect of the joint would be to change the speed of the mirror momentarily, the inertia of the flywheel resists such a tendency, provided the tape is slack enough to slip slightly. With this arrangement the image of the yarn can be made practically stationary, so that its behaviour can be accurately observed.

While the behaviour of the yarn was the main object for which the apparatus was devised, a side issue of importance soon showed itself. The apparatus had not been in use many minutes before large and unexpected variations in the speed of the spindles were discovered. To adapt the instrument for measurement of these variations, the marked paper band shown in Fig. 5 was stretched round the driving cylinder K (Fig. 2), and the mirror arranged to illuminate the driving cylinder and the spindles simultaneously. This band is divided into 40, 39, 38, 37, 36, 35, 34, divisions, the even number rows having marks about $\frac{3}{4}$-in. long and $\frac{1}{8}$-in. wide, and the odd numbered rows black spots $\frac{1}{4}$ in. diam. In the experimental frame, the driving cylinder is 10 in. diam. and the whorle on the spindle tube $\frac{3}{4}$ in. diam. The nominal speed of the spindle tube is therefore $10 \div \frac{3}{4}$ or $13\frac{1}{3}$ times that of the tin cylinder.

If the flash frequency given by the mirror is equal to the speed of such a theoretical spindle, the tin cylinder will turn $\frac{1}{13\frac{1}{3}}$ or $\frac{3}{40}$ of a revolution between flashes, so the band of 40 divisions will move forward an amount equal to three of its own divisions every flash. This band will therefore appear to be stationary. At the same flash frequency, the next band will have moved the same fraction of a circle between flashes, but here the pitch of the marks is slightly greater and the distance moved will be rather less than the distance between three marks. The band of marks will therefore appear to move slowly backwards. If the flash frequency be decreased by shifting the tape on the cone pulley until the 39 band appears stationary, the tin cylinder

will then be making $\frac{5}{39}$ or $\frac{1}{13}$ of a revolution between flashes. Table VIII shows the flashes per revolution of the tin cylinder when various bands appear stationary.

Table VIII.

Number of divisions in band apparently stationary ..	40	39	38	37	36	35	34
Flashes per revolution of cylinder	13⅓	13	12⅔	12⅓	12	11⅔	11⅓
Per cent. below nominal speed	0	2½	5	7½	10	12½	15

The intermediate percentages below nominal speed were determined by setting the mirror speed to bring the image of the nearest band stationary, and then counting the r.p.m. of the spindle image. The velocity ratio of spindle to driving cylinder could be determined to well within ¼ per cent. Measurement of absolute speeds could be made by reference to a tuning fork or other standard of frequency. With the help of the stroboscope used in the foregoing manner the variations of spindle speed were measured and the cause located. The instrument is, of course, still being used for its original purpose of investigating what happens to the rotating yarn.

As already stated, this type of stroboscope should prove useful in other fields than that for which it has been designed. There is nothing in the way of vibrating electrical contacts to limit the speed, and the only limitation is the mechanical strength of the rotating part. This could for higher speeds be made of a solid piece of stainless steel, with two or more faces, and there seems no reason why a flash frequency of over 100,000 per minute should not be attained. The revolutions of the mirror are, of course, equal to flash frequency ÷ number of faces. Neither the definition nor the illumination are effected by an increase of speed.

The Research Association are about to have a supply of these instruments made for its members, and will be pleased to increase the number (and so reduce the cost) if others interested will enter into communication with Mr. H. Blin, British Research Association for the Woollen and Worsted Industries. Torridon, Headingley, Leeds.

EXPERIMENTS ON THE NATURAL VIBRATION OF AEROPLANE SPARS.

By A. H. Stuart, Ph.D., B.Sc.

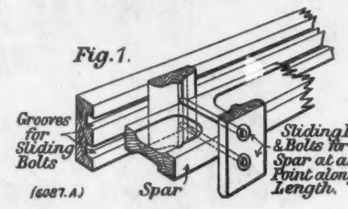
The experiments described below were made as a result of a few trials applied to an aeroplane which was giving vibrational trouble in the lower planes. The machine was of the Scout type with one pair of interplane struts, and there was reason to suspect sympathetic vibration in the main spar of the lower plane when the engine was running at its normal speed. The aeroplane was mounted with its flying axis vertical and a needle was secured to the free end of the main spar. A smoked glass plate was made to travel vertically in contact with the needle while the spar was vibrating and from the trace obtained it was established that the frequency of the spar vibration synchronised with the explosions of the engine. The effect of changing the point of contact of the interplane strut was tried, and it was found that the whole nature of the trace made on the smoked glass was changed. The graph showed a distinct harmonic character and the damping-out effect was much more pronounced. These graphs, however, were discussed in Report No. 386 of the Advisory Committee for Aeronautics (December, 1917) and in "The Vibration of Spars in Aircraft," Engineering, February 13, 1920, page 201.

To investigate the general behaviour of spars of non-uniform section fixed at one end and supported at a point in the neighbourhood of one-third of the length from the free end, a spar was mounted as shown in Figs. 1 and 2 annexed. The spar was carried in a horizontal position on steel balls placed between small steel plates, as shown in Fig. 2. The root of the spar was rigidly secured, while the point at which the strut fixture made contact was clamped by the arrangement shown in Fig. 1. At the free end of the spar a needle was fixed (see Fig. 2) so as to maintain contact with a smoked glass plate which could be made to travel uniformly in the frame shown by means of a clock-work device.

The spar was 14 ft. 8½ in. long and the clamp representing the strut fixture was first secured at a point 5 ft. 3 in. from the free end. A trace was obtained with the fixture in this position, and then at points moved successively in steps of 4 in. towards the free end, until a point 3 ft. 3 in. from the latter was reached. Reproductions of the seven graphs obtained are given in Fig. 3. The harmonic character of the graphs is at once suggested. One is apt to assume that this indicates that the spar is vibrating in its gravest mode with one or more harmonics superposed, but Lord Rayleigh has shown,* that, in the case of stiff bars (of which the spar may be assumed to be an example), the velocity of propagation of a wave is not independent of the wave-length, and therefore a complex wave cannot be propagated in a stiff bar without decomposition.

In view of this we must be prepared to find deviations from a true harmonic character in these traces. To test this point the graphs were submitted to harmonic analysis in the ordinary way. One fact became prominent in this work, the harmonic portion of the equation contained in every case only two terms, although search was made for additional terms no trace of such could be found.

Neglecting for the present the logarithmic decrement due to the damping-out effects, the equations obtained for these traces are given in Table I.



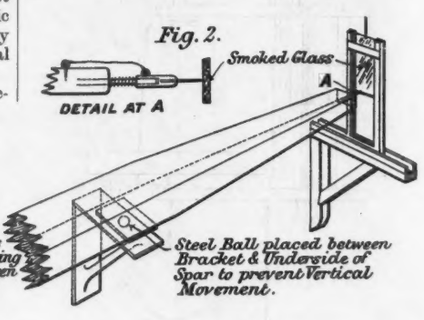


Table I.

Graph A	...	$y = \text{Sin } 7\,\theta + 0{\cdot}26 \text{ Sin } 10\,\theta.$
Graph B	...	$y = \text{Sin } 2\,\theta + 0{\cdot}33 \text{ Sin } 3\,\theta.$
Graph C	...	$y = \text{Sin } 7\,\theta + 0{\cdot}36 \text{ Sin } 11\,\theta.$
Graph D	...	$y = \text{Sin } 3\,\theta + 0{\cdot}50 \text{ Sin } 5\,\theta.$
Graph E	...	$y = \text{Sin } 5\,\theta + 0{\cdot}60 \text{ Sin } 9\,\theta.$
Graph F	...	$y = \text{Sin } \theta + 0{\cdot}75 \text{ Sin } \left(2\,\theta - \frac{\pi}{2}\right)$
Graph G	...	$y = \text{Sin } 4\,\theta + 1{\cdot}67 \text{ Sin } 9\,\theta.$

For convenience the amplitude of the second term is expressed in terms of that of the first.

These equations were then plotted, and the curves obtained appeared to be in very close agreement with the original traces. We are therefore faced with the fact that, in each case, the recording needle at the end of the spar performed two (and only two) harmonic motions. The relation between the wave-lengths of these vibrations is best seen by expressing the coefficient of θ in the second term of the equation in terms of that of the first term. The equations thus obtained are given in Table II.

Table II.

Graph A	...	$y = \text{Sin } \theta + 0{\cdot}26 \text{ Sin } 1{\cdot}44\,\theta.$
Graph B	...	$y = \text{Sin } \theta + 0{\cdot}33 \text{ Sin } 1{\cdot}5\,\theta.$
Graph C	...	$y = \text{Sin } \theta + 0{\cdot}36 \text{ Sin } 1{\cdot}57\,\theta.$
Graph D	...	$y = \text{Sin } \theta + 0{\cdot}50 \text{ Sin } 1{\cdot}66\,\theta.$
Graph E	...	$y = \text{Sin } \theta + 0{\cdot}60 \text{ Sin } 1{\cdot}8\,\theta.$
Graph F	...	$y = \text{Sin } \theta + 0{\cdot}75 \text{ Sin } \left(2\,\theta - \frac{\pi}{2.3}\right)$
Graph G	...	$y = \text{Sin } \theta + 1{\cdot}67 \text{ Sin } 2{\cdot}25\,\theta.$

Adopting these equations, the logarithmic decrement was determined in each case. Table III was then compiled, but it should be noted that the value for the logarithmic decrement is only an approximation, as the damping influences almost certainly affect the two component vibrations differently.

Table III.

Trace in Fig. 3.	Length of Bay (l_1) in Feet.	Length of Overhang (l_2) in Feet.	Ratio $\frac{l_1}{l_2}$	Ratio of Wave Lengths in Equation.	Amplitude of Second Term.	Log. Decrease.
A	9·46	5·24	1·805	1·44	0·26	0·019
B	9·8	4·9	2·0	1·5	0·33	0·027
C	10·13	4·57	2·22	1·57	0·36	0·030
D	10·46	4·24	2·47	1·66	0·5	0·033
E	10·8	3·9	2·77	1·8	0·6	0·035
F	11·13	3·57	3·12	2·0	0·75	0·037
G	11·46	3·24	3·54	2·25	1·67	0·038

It may here be pointed out that the traces were of a very stable character and were not dependent (within reasonable limits) on the magnitude of the force producing the vibration. It was quite easy to reproduce any graph by securing the strut fixture at the point indicated in the Table III. Of the two harmonic motions performed by the end of the spar, it is reasonable to suppose that one was due to the spar vibrating in its gravest mode. If the second harmonic motion were due to a vibration of the whole spar of an order higher than that of the gravest mode, there are two points which we might expect to be evident: (1) Owing to decomposition of the complex wave the motion of the needle would not have produced a trace of so harmonic a character. (2) The ratio of the frequency of the vibration of the gravest form to that of a "harmonic" would be of the order of 2 or more, whereas in the cases considered this ratio falls as low as 1·44.

Although the traces are not shown in Fig. 3, the experiments were continued with the strut fixture moved towards the root of the spar until a point 6 ft. 7 in. from the free end was reached. These traces appeared so nearly alike and so closely resembled true sine curves that their analysis presented some difficulty. A careful examination of them revealed, however, that they too represented two harmonic motions, the ratio of the wave-lengths of which approached unity as the strut fixture was moved towards the root of the spar, and the shorter wave of which was of very small amplitude. Table IV gives the series of equations obtained with the respective positions of the strut fixture.

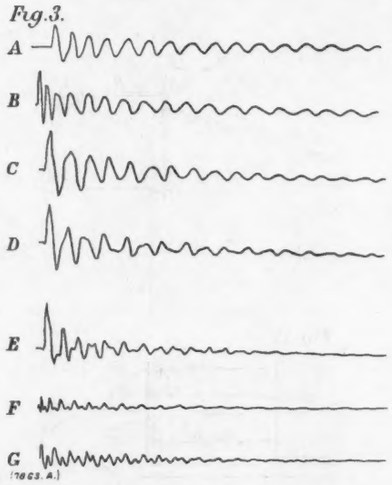


Table IV.

Graph.	Length of Overhang (l_2) in Ft.	Equation of Trace.
B in Fig. 3	4·9	$y = \text{Sin } \theta + 0{\cdot}33 \text{ Sin } 1{\cdot}5\,\theta.$
A in Fig. 3	5·24	$y = \text{Sin } \theta + 0{\cdot}26 \text{ Sin } 1{\cdot}44\,\theta.$
	5·57	$y = \text{Sin } \theta + 0{\cdot}22 \text{ Sin } 1{\cdot}4\,\theta.$
	5·9	$y = \text{Sin } \theta + 0{\cdot}17 \text{ Sin } 1{\cdot}38\,\theta.$
	6·24	$y = \text{Sin } \theta + 0{\cdot}12 \text{ Sin } 1{\cdot}35\,\theta.$
	6·57	$y = \text{Sin } \theta + 0{\cdot}10 \text{ Sin } 1{\cdot}33\,\theta.$

A careful consideration of these facts seems to point to the conclusion that the shorter wave of these two harmonic motions was the result of the whole spar vibrating in its gravest mode, while the longer wave was the result of the overhanging portion vibrating independently. This hypothesis

* "The Theory of Sound," vol. i, Chapter viii.

would account for the fact that the relative amplitude of the second term of the equation (which represents the vibration of the spar as a whole) diminishes rapidly as the length of the bay is decreased.

It may be observed that if the spar were of uniform section the frequency of the vibration of the overhanging portion (assuming that it is vibrating independently) would be inversely proportional to the length; that is, the product of the length and the frequency should be a constant. This point is tested in Table V. It must be borne in mind, however, that the spar is tapered and possesses other irregularities of section, but these irregularities are not considered to be of sufficient magnitude wholly

TABLE V.

Graph.	Frequency of Vibration per Second.	Length of Overhang (l_2) in Feet.	Product.
B in Fig. 4	11·6	4·9	56·8
A in Fig. 4	11·3	5·24	59·2
	10·4	5·57	57·9
	9·6	5·9	56·7
	9·1	6·24	56·8
	8·7	6·57	57·2
		Average ..	57·4

to invalidate the test. The frequencies given in Table V were obtained by counting the complete wave-lengths on a given length of the trace, the rate of movement of the glass being known, viz., 3·56 in. per second. Considering all the circumstances of the case, the agreement appears to be very satisfactory.

In comparing the relative frequencies of the vibrations indicated by the equations given in Table II it must be remembered that although the first term in each equation is written Sin θ it is not thereby implied that the frequency is the same throughout. Indeed, if this term represent the independent vibration of the overhanging portion, it is clear that the frequency will increase as the length in the overhang diminishes. Moreover, this increase is certain to be of a higher order as we approach the free end, since, as we move the strut outwards, we not only make the length of the overhang shorter, but confine it more and more to the tapered (that is thinner) end of the spar.

To obtain an approximate indication of the relative frequency of the spar vibrating in its gravest mode, assuming the hypothesis given above, we may proceed as follows. Let the equation representing A in Fig. 3 be written $y = \text{Sin}\ \theta + 0{\cdot}26\ \text{Sin}\ 1{\cdot}44\ \theta$. Now proceeding to graph B, the θ of the first term of the equation given in Table II represents a shorter wave than the θ of the equation A. To put the two equations on an equal time scale we must give the θ of equation B a coefficient inversely proportional to the frequency it represents.

Since the frequency of the overhang (according to the hypothesis) is approximately inversely proportional to its length, the coefficient required will be the length of the overhang corresponding to equation B divided by that corresponding to equation A, or $\frac{4{\cdot}9}{5{\cdot}24} = 0{\cdot}935$. This will reduce the coefficient of θ in the second term of the equation from 1·50 to 1·40. Including the additional equations given in Table V, but excluding the equations E, F and G, in Fig. 3 (since these refer to conditions in which the overhang is largely confined to the tapered end of the spar) we may compile Table VI.

TABLE VI.

Graph.	(l_2) in Ft.	Equation.
	6·57	$y = \text{Sin}\ 1{\cdot}255\ \theta + 0{\cdot}10\ \text{Sin}\ 1{\cdot}67\ \theta.$
	6·24	$y = \text{Sin}\ 1{\cdot}19\ \theta + 0{\cdot}12\ \text{Sin}\ 1{\cdot}61\ \theta.$
	5·9	$y = \text{Sin}\ 1{\cdot}126\ \theta + 0{\cdot}17\ \text{Sin}\ 1{\cdot}555\ \theta.$
	5·57	$y = \text{Sin}\ 1{\cdot}063\ \theta + 0{\cdot}22\ \text{Sin}\ 1{\cdot}49\ \theta.$
Fig. 3, A	5·24	$y = \text{Sin}\ \theta + 0{\cdot}26\ \text{Sin}\ 1{\cdot}44\ \theta.$
B	4·9	$y = \text{Sin}\ 0{\cdot}935\ \theta + 0{\cdot}33\ \text{Sin}\ 1{\cdot}4\ \theta.$
C	4·57	$y = \text{Sin}\ 0{\cdot}872\ \theta + 0{\cdot}36\ \text{Sin}\ 1{\cdot}37\ \theta.$
D	4·24	$y = \text{Sin}\ 0{\cdot}810\ \theta + 0{\cdot}50\ \text{Sin}\ 1{\cdot}344\ \theta.$

A careful measurement of trace A in Fig. 3 shows the frequency of the vibration represented by the first term of the equation to be 11·3 vibrations per second. This would give the frequency of the whole spar in its gravest mode, with the strut at this position, as 16·3 vibrations per second. From this we may obtain the frequency of the grave vibration of the whole spar for all the positions of the strut fixture recorded in Table VI. One point is observed in these figures, viz., the frequency of the gravest vibration is very nearly inversely proportional to the length of the bay (l_1 in Table III). This relation is illustrated by the product of the frequency and l_1 given in Table VII.

TABLE VII.

Length of Bay (l_1) in Feet.	Length of Overhang (l_2) in Feet.	Approximate Frequency of Gravest Vibration per Second.	Product of Frequency and l_1 to nearest Whole No.
8·13	6·57	18·9	154
8·46	6·24	18·2	154
8·8	5·9	17·5	154
9·13	5·57*	16·9	154
9·46	5·24*	16·3	154
9·8	4·9*	15·8	155
10·13	4·57	15·5	157
10·46	4·24	15·2	159

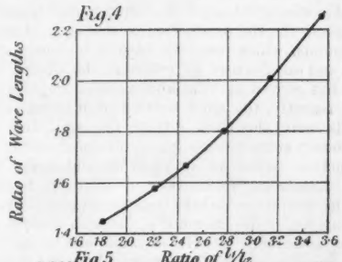


Fig.5. Ratio of l_1/l_2

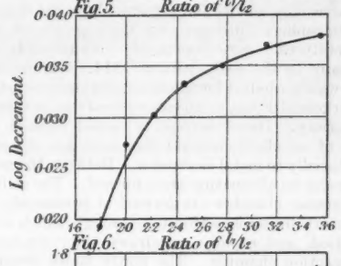
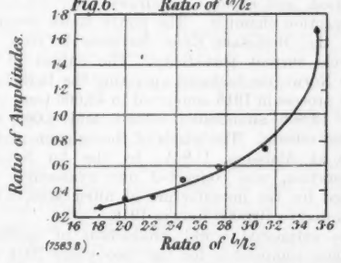


Fig.6. Ratio of l_1/l_2



(75838)

Further evidence of a regular relationship between the ratio of the lengths in the bay and overhang, and the ratio of the wave-lengths of the vibrations produced is given in Fig. 4, while the influence of the length ratio upon the logarithmic decrement and the relative amplitude is shown in Figs. 5 and 6, respectively.

Measurements made on a number of different makes of aeroplanes of the Scout type show that designers favour a position on the spar for the strut fixture which allows an overhang ranging from 33 per cent. to 37½ per cent. of the whole length. This range is covered by the cases marked with an asterisk in Table VII. Dangerous resonance would doubtless occur if the spar were subjected to periodic impulses of the frequency indicated in Table VII or Table V. These frequencies appear to be the lowest that will normally occur, but it is highly probable that vibrations of a higher order would be possible under conditions which favoured their production.

THE INDUSTRIAL APPLICATIONS OF THE ELECTRIC FURNACE.

By E. W. LEWIS.

THE outstanding characteristics of the electric furnace are the highly constant and regular heat distribution and the accurate automatic control of the temperature, features which considerably reduce cost and tend towards the production of a better finished product. The use of the electric furnace has expanded so as to penetrate into a wide range of chemical and metallurgical operations and thermal processes generally.

The first large-scale industrial application of the electric furnace was conducted at Cleveland, U.S.A., in 1885, by the Cowles Electric Smelting and Aluminium Company, although the first electric furnace had been built at Philadelphia in 1810 by Hare, who, by means of a voltaic pile, isolated metallic carbon and also prepared calcium carbide. The commercial application of the electric furnace and its early development, was focussed on the search for an economical means of producing metallic aluminium. The introduction of the dynamo as a source of electricity gave a tremendous impetus to the applications of the electric furnace, as it afforded a more economical means of producing the current and could be applied in larger quantities.

The two types of electric furnaces generally used are the induction, and arc, or modifications of two types. The induction furnace consists substantially of a laminated core transformer with primary and secondary coils. These furnaces generally operate in single phase, but by the application of a simultaneous motor-driven generator and setting the load on the central station, they can be operated polyphase at leading power factor. The advantages offered by the induction type of furnace are: there is complete elimination of electrode contamination, the temperature is easily controlled, a perfectly homogeneous product is obtained, the power may be high and the load maintained within fairly narrow limits. The development of induction furnaces has not kept pace with metallurgical operations, and at the present time, the arc type easily outnumber induction furnaces in prominent modern industrial applications, particularly in the metallurgy of steel, ferrous and non-ferrous metals and alloys. The outstanding difficulty experienced with induction furnaces has been to find a suitable lining material to withstand the heat, and the demand for the use of an exceedingly low frequency power.

The majority of the arc furnaces are built on the Heroult principle, which is a steel casing, lined with a heat-resisting material, the electrodes being suspended from the roof. The heating is effected by the arcs formed between either two or three carbon electrodes—consequent on the use of a three or single-phase current—and the metal to be treated. In several types of modern furnaces, application is made of the combined principles of the arc and resistance. The fluctuation of the power load taken by the furnaces is adjusted by automatic control of the electrode motors, an equipment which has considerably eliminated the difficulties experienced in older installations from the load standpoint. The transformers are arranged so as to counteract the momentary short circuits and to deliver heavy current at a low voltage. Arc furnaces vary in capacity from 1 ton to 40 tons. For the melting of steel castings the kilowatt-hour varies from 500 to 600 per ton, for refined steel and castings from 700 kw.-hours to 1,200 kw.-hours per ton. The temperature of the positive carbon in an arc furnace is estimated at about 3,700 deg. C.

Alternating current is used in the industrial applications of the electric furnace, direct current has been found to be detrimental, due to the electrolytic action on the material treated. In the case of alternating current any desired voltage can also be obtained by transformation of the power supply potential. A high economy is obtained from the generator by obtaining a current on a large scale at a high potential, the current is transformed to a still higher potential when transmitted to a distance and finally toned down to conform to the individual furnace requirements. By transformer regulation, the voltage may also be adjusted without loss of power.

Various types of furnaces have been devised for particular processes. For the heat treatment of metals, the furnaces used are of the resistance type, the heating being effected by radiation. Some of the continental furnaces used for the annealing of turbine castings have assumed huge dimensions.

1. *Smelting of Iron Ores.*—The electric smelting of iron ores is now conducted extensively in California, Canada and Sweden, and its application

in the manufacture of pig-iron is successfully competing with old-established fuel heated processes. Electric smelting of iron ores is advantageous in (1) a superior iron and steel is produced by the elimination of gaseous impurities, (2) the introduction of impurities is reduced to a minimum, and more complete removal of phosphorus and sulphur is attained, consequent on the application of a higher temperature, and hence the use of a more basic slag; (3) the melting and reducing zone temperatures are more readily controlled, and the gases obtained during the smelting are of a higher calorific value than those usually obtained in blast-furnace practice.

The type of furnace which has been found to be most serviceable is the Elektrometall furnace. It consists of a tubular shell in which the ore is partially reduced by the combustion gases from the crucible below in which the charge is melted. The shaft is so arranged, that a stream of hot gases pass up the shaft and through the incoming charge, by a judicious regulation of which the temperature may be controlled and the electric power economically applied. The evolving gases are collected and supplied to blast furnace pipes entering between the electrodes. On withdrawing the metal it may either be cast into pigs or transferred directly to the steel furnace. In modern practice, firebricks are replacing magnesite as a furnace lining. The electrodes used are circular, about 2 ft. 6 in. in diameter and 5 ft. long; in the larger type of furnace six electrodes are used provided with three-phase current from three transformers. The voltage of the transformers is regulated by tapping of the primary windings, which also affords a ready means of regulating the electric powers. The cast-iron produced in Sweden during 1918 by electric furnaces amounted to 100,000 tons, which is 15 per cent. of the total manufactured (J. du Four "Electrique," 1919, vol. xxviii, page 17).

During 1917 and 1918, the technique of the electrometallurgy of pig-iron was exhaustively investigated in France. The power consumption was found to be from 675 kw.-hours to 800 kw.-hours per ton of iron, and the power factor of the furnaces 80 per cent. on 60-cycle current, with a phase voltage of 50 volts to 75 volts. High grade grey irons are also being refined in electric furnaces. Cupola iron after basic electric furnace treatment shows an increased transverse strength and reduction in sulphur content, the iron being used for high-grade castings.

2. *Manufacture of Steel.*—One of the most successful industrial applications of the electric furnace is in the manufacture of steel. In 1908, the steel manufactured in the United States of America by electric furnace processes was 60 tons, in 1918 the output was 512,000 tons. In 1918, the Illinois Steel Company installed 12 electric furnaces, each of 30 tons capacity for the treatment of steel by a combined bessemer-open hearth-electrical process. The introduction of the electric furnace into the steel industry was slow, consequent on the changes of magnitude in methods and equipment. During the war, steel electrometallurgy developed rapidly, and enabled the ferro-alloy and steel industry to meet new and increased demands for the production of new and better quality products. The development of the electrical production of steel was much facilitated, consequent on the abandonment of a large number of carbide plants in Sweden and France. Kjellin in Sweden applied a number of these plants for the manufacture of high-grade steel and ferro alloy manufacture, particularly for the production of ingot alloy steels for automobile construction, and also for high-speed steel. The electric furnace has proved highly successful in the manufacure of alloy ingots, such as ferro-silicon, ferro-tungsten, ferro-titanium and ferro-chrome. In 1914, there were no plants in operation producing ferro-manganese electrically, in 1918 there were 10 plants in the United States of America alone, with a total output of 80,000 tons a year. Three-phase furnaces have been found to be most economical for the ferro-alloys of silicon, manganese and chromium, on account of lower melting-point, and single-phase for those of molybdenum, vanadium, uranium and titanium. The general applications of electricity to the steel industry, offers the best immediate field for new outlets and applications of large requirements of electrical power. The potent advantage of the electric furnace in the steel industry is in the production of a high grade and uniform material at a low cost of operation. It is particularly applicable to foundry practice, and for the melting, refining and casting of iron and steel. In the production of alloy steels, the loss of alloyed metal due to oxidation is considerably less in electrical processes than in fuel-heated furnaces. Those furnaces used in low-temperature melting and annealing are usually of the muffled or resistance type, and are used considerably in annealing castings and hardening steels.

The rapid development of the electric furnace during recent years, has made possible the progress of metallurgical operations, and placed the industry in a position of first-class importance. The superior quality of electrically-produced steel is established, and the easy production and maintenance of high temperatures affords facilities for the production of difficultly fusible alloys.

3. *Fixation of Atmospheric Nitrogen and Ammonia Oxidation.*—In the production of synthetic nitrogen compounds, which form the base of modern explosives, and are also used as fertilisers, the electric furnace has proved of vital and national importance. Until recently, the chief sources of nitrogen compounds were the Chili nitrate deposits, and the by-product ammonium sulphate obtained during the destructive distillation of shale oil and coal. The first commercial application of nitrogen fixation was the arc process, where the oxygen and nitrogen combine under the influence of the high-tension arc.

The researches of Haber and others on the synthesis of ammonia and nitric acid, by the fixation of atmospheric nitrogen at high pressures and temperatures, were operated commercially in Germany in the early part of 1914. The method most widely applied for the nitrogen synthesis is that of Berkeland-Eyde, a process successfully developed in Norway. Direct current is passed through the poles of an electromagnet, the poles are arranged equatorially to metal electrodes. Between the metal electrodes an alternating arc is formed. The walls of the furnace chamber are formed of brickwork, the refractory lining is perforated through which air is admitted, and rapidly withdrawn after traversing the reaction chamber. The power factor obtained with the Berkeland-Eyde furnaces is 0·65, at 50-cycle current periodicity. The output of the three Norwegian factories operating the Berkeland-Eyde process in 1916 amounted to 40,000 tons nitric acid, 10,000 ammonium nitrate and 6,000 tons sodium nitrate. The whole of the calcium carbide made at Alabama, U.S.A., by the Air Nitrates Corporation, was converted into cyanamide and applied for the manufacture of nitric acid, which amounted to 100,000 tons in 1918.

The estimated world production of synthetic nitrogen compounds for the two years 1914 and 1918, is as follows (Landis. Trans. Amer. Electrochem. Soc., 1918, 34, page 105).

Compound.	1914. Nitrogen. Tons.	1918. Nitrogen. Tons.
Nitre	386,400	472,700
Ammonium sulphate ...	259,000	300,000
Cyanamide	28,000	327,500
Synthetic ammonia and miscellaneous ...	11,000	105,500

In England, the Billingham-on-Tees factory commenced operations in 1918, under the direction of the Ministry of Munitions, for the manufacture of synthetic ammonium nitrate, later, the factory was taken over by Messrs. Brunner, Mond and Nobel Industries, Limited, for the production of nitrates to be used in fertiliser and explosives manufacture.

4. *The Electric Furnace in the Automobile Industry.*—The electric furnace is now used extensively in the automobile industry, and is destined to become common practice even at a slightly higher cost, consequent on the ease of control, and also the regularity and uniformity of the results obtained. The facility with which the temperature can be controlled, has proved to be invaluable in baking the japan used on motor bodies, and in the annealing and japanning of small parts. The electric furnace provides a clean atmosphere, giving a better finish to the highly-polished parts. One of the Ford factories, U.S.A., contains an electric furnace, forming a connected load of 14,000 kw., for the heat treatment of motor bearings. The carbon resistance type of furnace has been widely installed. The furnaces have been ingeniously designed, with a control movement through the furnace of the bearing treated, and a highly developed automatic control of temperature. The heating is effected by carbon electrodes immersed in a trough of sand, the load being controlled by variation of the secondary voltage with taps of a special type of transformer.

A highly efficient type of furnace was developed in war time for the heat treatment of gun barrels, and has since been adapted to the motor industry. The heating unit comprises a ribbon of chrome-nickel alloy, which is supported by a cast-iron plate with an insulation of refractory material. The units used are of 400-kw. and take three-phase current at 440 volts. The temperature is controlled by an automatic cast-off arrangement around a fixed temperature. There is an increased proneness towards three-phase Heroult type furnaces with high power, low resistance circuits and automatic electrode control.

5. *Manufacture of Calcium Carbide.*—The electric furnace has been applied for the commercial production of calcium carbide, which is used for the generation of acetylene, and as an intermediate for the production of cyanamide. Essentially the reaction consists of the heating of lime and carbon to a temperature of about 2,000 deg. C. The best furnaces in use are of the smothered arc type, in which small arcs exist due to the movement of the charge, the best product is obtained by the use of alternating current, but self-induction difficulties appear to be of frequent occurrence.

The application of acetylene as a base for the synthesis of nitrogen products, has created a considerable demand for calcium carbide, an important innovation in war time was the use of acetylene in the synthetic production of alcohol, acetic acid, acetone and cellulose acetate. The manufacture of synthetic products from acetylene is being extended enormously at the works of the British Cellulose Company, at Spondon, Derby. In 1918, the United States Government installed a large carbide plant at Muscle Shoals, Alabama, for the manufacture of nitrates for fertiliser and explosives manufacture.

6. *In the Glass Annealing and Silica Industries.*—In the annealing of glass, the electric furnace is rapidly supplanting the fuel fired furnace, due to the accurate control of temperature, uniformity of the heat application, and the even distribution of the heat. In the glass industry, it is essential that the heat should be maintained within narrow limits for lengthened periods, and it is in this respect that the electric furnace finds its superiority.

The manufacture of fused silica vessels, large pipes and basins for sulphuric acid concentration, is conducted by the Thermal Syndicate, Limited, at Wallsend-on-Tyne. The features of fused silica vessels are their high melting-point, resistance to corrosion, hardness, and ability to resist without fracture sudden and extreme changes of temperature, the latter quality being due to its low coefficient of expansion, which at 200 deg. C., is 518×10^{-9}, and at 1,100 deg. C. $= 583 \times 10^{-9}$ (*Met. and Chem. Eng.*, 1920, 22, page 593). The silica is heated in an electric furnace to its melting-point (1,800 deg. C.), and moulded to the desired shape.

7. *General Industrial Applications.*—Among other applications of the electric furnace are, baking japan on to typewriters and telephone parts, baking steel wires, drying explosives and chemicals, and for sterilising surgical instruments. Ferro-silicon is produced by heating a mixture of silica, iron and coke in an electric furnace, ferro silicon has found application as a deoxidising agent in steel manufacture, and in war time—in admixture with soda and lime—appeared under the name of "hydrogenite" as a source of hydrogen for aeronautical purposes. Portable generators were used capable of producing 10,000 cub. ft. of hydrogen per hour.

Graphite which is finding wide applications for crucible and electrode manufacture, is prepared by treating powdered anthracite between the arc electrodes of an electric furnace. "Aloxite" and "exolon" are the patent names for superior abrasives prepared by treatment of bauxite in an electric furnace. Alundum refractory materials consists of fused bauxite combined with a binding agent, and

COAL-MEASURING MACHINERY AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY THE LEA RECORDER COMPANY, LIMITED, ENGINEERS, MANCHESTER.

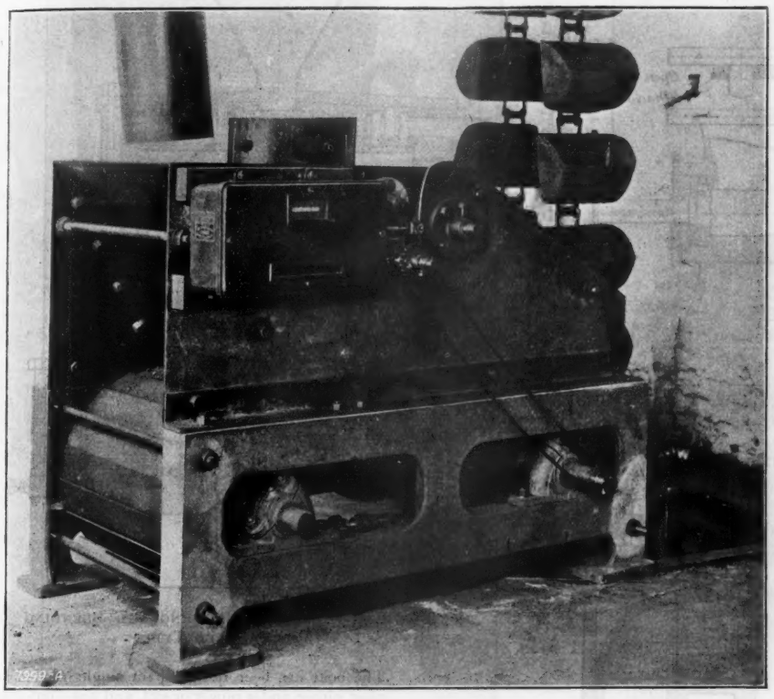
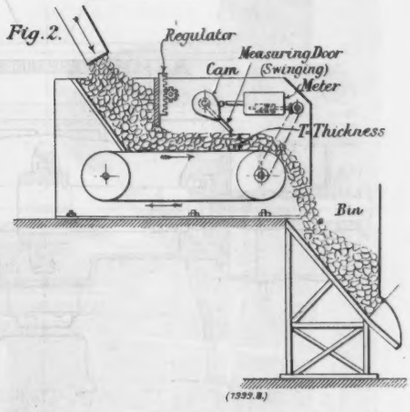


FIG. 1. THE LEA CUBIMETER.



annealed at high temperatures. Commercial experiments are now being conducted for the preparation in the electric furnace of metallic borides, in view of their remarkable abrasive powers, it being claimed that they are superior to alundum and carborundum in hardness and durability.

The melting of brass and the treatment of copper ores by means of the electric furnace, are conducted extensively in France. The electrical treatments of tin ores and dross have been carried out as commercial experiments in Cornwall and the Straits Settlements, with plants built by Harden and the Gröndall Kjellin Company.

Metallic phosphorus is now prepared almost exclusively by electro-thermal methods, the electric furnace being peculiarly applicable as internal heating is effected, and the phosphorus is protected from oxidation during distillation. The process consists essentially of the smelting of phosphates with carbon and silica, with distillation of the metallic phosphorus.

An electric furnace plant for the production of carbon bisulphide is operating at Penn Yann, U.S.A. (Trans. Amer. Electrochem. Soc., 1902, I, page 115), water power is used and the production amounts to 95 per cent. of the carbon bisulphide of the United States output, the older processes having been rapidly displaced. Electric welding, which is an application of the arc furnace, was considerably developed in war time, and is now being used for a great variety of purposes, including the welding of boiler plates.

In a large number of industrial processes, the application of the electric furnace offers economic, æsthetic and industrial advantages over the older thermal and metallurgical processes, and has opened up fields of engineering and chemistry previously inaccessible, due to the difficulty of production of high temperatures. The phenomenal development of the electrochemical industries has followed economical power production, and the general applications of electrical engineering. Carpenter (*Nature*, 1919, vol. civ, page 243), says that "for high-grade materials, such as high-speed cutting tools, where quality is of paramount importance, the electric furnace seems to have a field all its own."

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

IN our comments on the occasion of the previous exhibition of this kind, which was held at Olympia during October, 1919, we remarked upon the unpropitious circumstances which attended its opening. Not only was there considerable general labour unrest due to the unsettled conditions after the war, but the railway strike at the time exerted a further unfortunate influence. The exhibition which opens at Olympia to-day takes place in a very different atmosphere. Order books which were so congested in 1919 that manufacturers would hardly guarantee any date at all for delivery, are now pitifully empty. The post-war boom spent itself with an almost startling suddenness, and for nearly three years there has been acute depression in industry. Prices have been cut and such orders as could be obtained have been taken at a loss for the sake of keeping the works even partly going, and there is no immediate prospect of any considerable revival in trade. The outlook, however, is not wholly dark. A courageous determination on the part of the Government to place and maintain the national finances in a sound condition has put the credit of the country upon a plane immeasurably superior to that of any European belligerent nation, and the reward for our fiscal honesty has been the comparative cheapness with which necessary raw material and foodstuffs can be purchased abroad.

The unsettlement of Europe is undoubtedly bad for commerce, but it is absurd to take it too tragically. The deficit of wheat and other agricultural products from Russia has been more than counterbalanced by greater supplies from other parts of the world. Most of the other belligerent continental countries were formerly acute competitors with us in our own and foreign markets, and the loss of their custom may be set off by the absence of their competition with our own manufacturers. The undeveloped countries of the world must buy machinery and manufactured goods, and among the manufacturers of Europe, the British are certainly in the best position to obtain the trade. Our industrial supremacy was largely built up while Europe was unsettled by the Napoleonic and other wars, and it may again be consolidated by the present state of affairs on the Continent. With a hope that the present exhibition at Olympia may even, in a small way, do something towards restarting the wheels of industry, we may turn to a consideration of some of the exhibits which will be of interest to our readers.

The Lea Recorder Company, Limited, of 28, Deansgate, Manchester, whose water measuring instruments are so well known to power station engineers and others, turned their attention some years ago to the question of providing a practicable apparatus for the continuous measurement of the coal passing to the boilers, and produced a coal meter to register the quantity of fuel burnt on chain grate stokers. The registering mechanism, which was operated jointly by the speed of the grate and the opening of the fire-door, showed the volume of the coal passed on to the grate, and from its readings the weight of coal burnt could be computed with quite sufficient accuracy for practical purposes. The engineer thus had means for knowing the coal burnt and the water evaporated during every shift, without which knowledge the highest operating efficiency is impossible to obtain. A coal meter of the kind referred to is exhibited by the Lea Recorder Company, but of perhaps greater interest is a later development of the idea, as embodied in the Lea "cubimeter" illustrated in Figs. 1 and 2 on this page. This is a self-contained apparatus, for automatically and continuously measuring coal or any other granular material which is passed through it. The principle of its action will be clear on reference to Fig. 2. The coal is fed into a hopper beneath which is a short travelling-plate conveyor. The latter carries forward a quantity of coal which is regulated by a sliding door to suit the delivery required. Resting on top of the coal is a hinged flap, the angular position of which is determined by the thickness of the layer. A cam which moves solidly with the flap actuates a horizontal rod and determines the position of a counting pinion which gears with a toothed cylinder. This cylinder is driven by a chain from the conveyor shaft so that its speed of rotation is in constant proportion to that of the conveyor. The teeth of the cylinder are cut away in a spiral fashion so that the number which engage with the sliding pinion during one revolution of the cylinder is proportional to the distance which the pinion happens to be along the cylinder. It is thus clear that the

EXHIBITS AT THE SHIPPING AND MACHINERY EXHIBITION AT OLYMPIA.

CONSTRUCTED BY THE CHEMICAL ENGINEERING COMPANY (MANCHESTER), LIMITED, MANCHESTER.

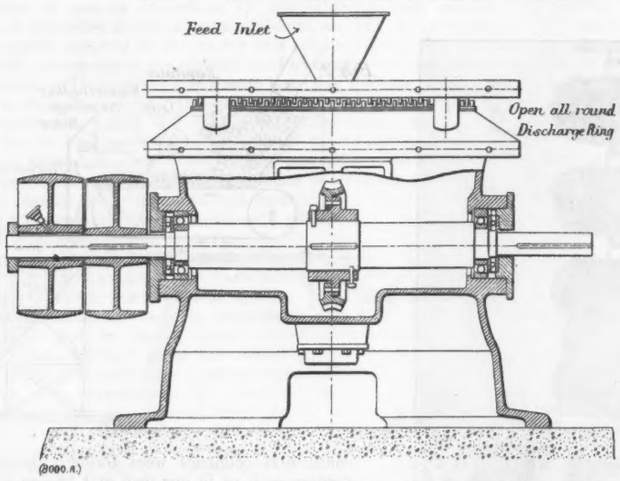


Fig. 3. Centrifugal Grinding and Blending Mill: Open Type.

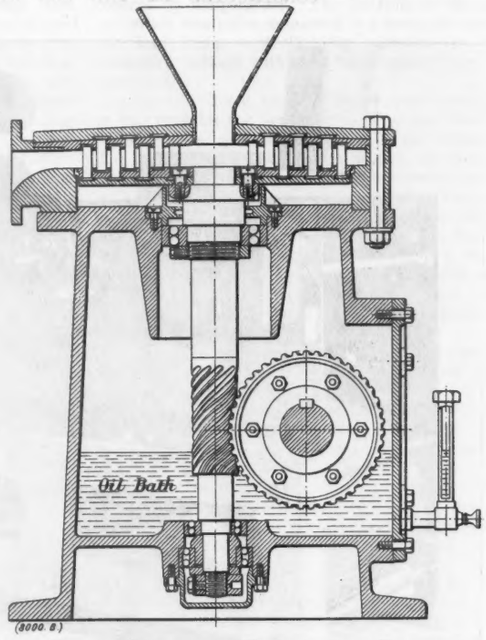


Fig. 4. Centrifugal Grinding and Blending Mill: Closed Type.

number of revolutions made by the pinion, and therefore by the registering mechanism, in a given time is jointly proportional to the speed of the conveyor and to the thickness of the layer of coal; or in other words, to the number of cubic feet of coal which have passed during the time. Experience has proved that the measurement of coal in this way gives results which are quite comparable in accuracy with any other routine measurements in a power station, not excluding those of the electricity generated, and any greater refinement than this is of course useless. The cubimeter principle can equally be applied to the measurement of coal delivered by existing belt-conveyors, but the self-contained unit, as illustrated, is generally preferable.

The Chemical Engineering Company (Manchester), Limited, of 49, Deansgate, Manchester, are showing the "Kek" patent centrifugal pulverising and blending mill which works on the well-approved principle of subjecting the material to be pulverised to innumerable blows from rapidly moving pins. The construction adopted will be clear on reference to Figs. 3 and 4, annexed. A horizontal driving shaft carries a worm wheel which gears with a multiple threaded worm on the vertical spindle. This spindle at its upper end carries a horizontal plate, slightly dished and fitted with concentric rows of manganese steel pins. Immediately above it is a similar fixed plate the pins of which form alternate rows with those of the moving plate. The material to be pulverised is introduced through the centre of the fixed plate and works its way to the circumference by which time it is transformed to the finest powder. When fitted with an all-round discharge ring, as indicated in Fig. 3, the machine can be used not only for dry materials such as minerals, cereals, chemicals, dyes, &c., but also for substances in a semi-liquid or pasty condition. It will emulsify mixtures of oils and water or reduce solids to a state of permanent suspension in liquids. The mill has proved very successful in making stone dust for preventing explosions in mines. A machine with discs 26 in. diam. driven at 3,000 r.p.m. by a 25 b.h.p. motor has reduced 20 cwts. of cobbles per hour to a dust of which 64·7 per cent. would pass a screen having 200 meshes per linear inch, and not more than 27·8 per cent. was retained by a screen with 100 meshes per inch.

Another exhibit by the Chemical Engineering Company, Limited, is the "Kek" anti-corrosion injector illustrated in Fig. 5 on the present page. The object of the device is to protect economiser tubes from the external corrosion which is often so serious unless the feed water is introduced at a comparatively high temperature. With cold feed water the tubes "sweat" owing to the condensation upon them of the vapour in the flue-gases, and

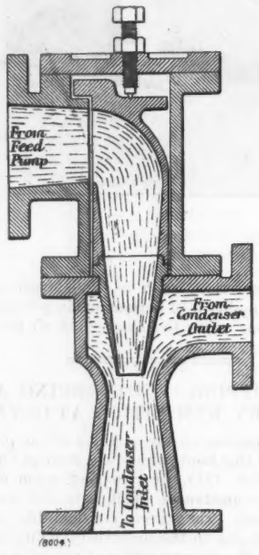


Fig. 5. The Kek Injector for Economisers.

sulphuric acid is formed on their surfaces from the sulphur in the fuel. To obviate this sweating it is necessary that water shall not enter the economiser at a temperature lower than about 110 deg. F. This is ensured by mixing some of the hot outlet water from the economiser with the cold feed water, before the latter reaches the tubes. The mixing is effected automatically by the injector illustrated, the cold water from the pump entering the system through a nozzle and drawing with it a certain proportion of the water already heated. The circulation of water through the economiser tubes is more rapid than without the injector, because the quantity in motion is greater than that which the boilers are evaporating. The higher speed of flow through the tubes assists the rate of heat transfer from the flue-gases and increases the efficiency of the whole apparatus.

Messrs. John I. Thornycroft and Co., Limited, of Basingstoke, Southampton and Smith-square, London, who have one of the largest stands in the motor boat and marine section of the exhibition, have a striking display of motor boats, marine and stationary engines, oil fuel apparatus, &c. Prominent on the stand is a 35 ft. sailing motor boat with mahogany hull and equipped with a Thornycroft engine of 9 b.h.p. The boat has been designed for single-handed running, either under power or sail, and has comfortable accommodation for sea cruising. A 20-ft. clinker-built ship's boat with an engine developing 7·5 b.h.p. on paraffin, and a 30-ft. open river launch are also to be seen. The largest engine shown by Messrs. Thornycroft is a 12-cylinder engine with reverse gear, developing 375 b.h.p., similar to those supplied by the firm for hydroplanes, and coastal motor boats for the Admiralty. The engine illustrated in Fig. 6 on page 261 is a four-cylinder marine motor of 30 b.h.p. to 36 b.h.p. for use with either petrol or paraffin as fuel. It is fitted with reversing gear and forms a compact and efficient unit. Fig. 7 on the same page shows an emergency ship-lighting set of the type supplied to the Cunard, Canadian Pacific, Nippon Yusen Kaisha and other leading shipping companies. The engine, which develops 75 b.h.p. to 100 b.h.p., is coupled direct to its dynamo, the whole being mounted on a continuous cast-iron bedplate. A cooling radiator with a fan driven by a belt from the engine renders the set self-contained. The engine will run on either paraffin or petrol.

Messrs. Perman and Co., Limited, of 82 and 83, Fenchurch-street, London, are showing two British Kromhout marine oil engines, constructed by Messrs. Day, Summers and Co., Limited, of Southampton. The larger engine, which we illustrate in Fig. 8 on page 261, is of the two-cylinder type designed to develop 100 b.h.p. at 320 r.p.m. A single-cylinder engine of 15 b.h.p. at 500 r.p.m., built at the Kromhout works in Amsterdam and direct coupled to a dynamo for lighting purposes, is also exhibited, together with various working parts of an engine rated at 500 b.h.p. All the engines exhibited use heavy oil and work on the two-cycle system with surface ignition. For starting purposes a specially rapid design of heater is fitted, which will enable an engine to be got away in from two to five minutes according to its size. Reverse gear is fitted to the smaller engines, but in sizes over 275 b.h.p. compressed air is used to reverse the direction of rotation of the engines, pre-ignition being never employed for the purpose. In the air-reversing type the fuel feed pumps are operated by cams, the cam shaft also operating the air valves. The cam shaft can be moved in a fore and aft direction by hand when the engine is either

ENGINES AT THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

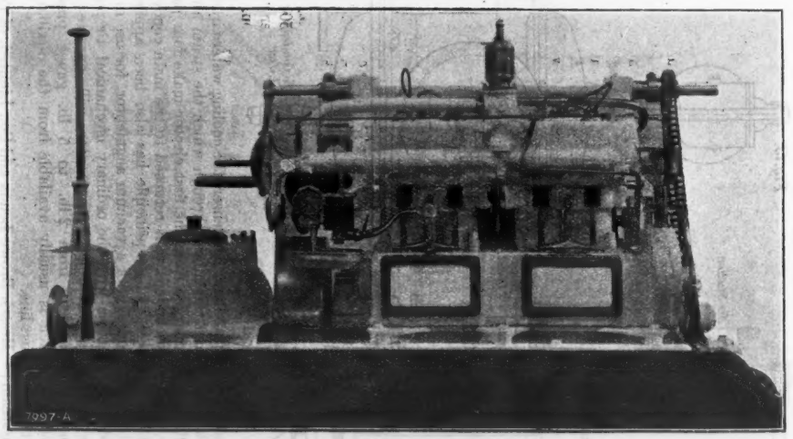


FIG. 6. 30-B.H.P. MARINE MOTOR WITH REVERSING GEAR; MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, BASINGSTOKE.

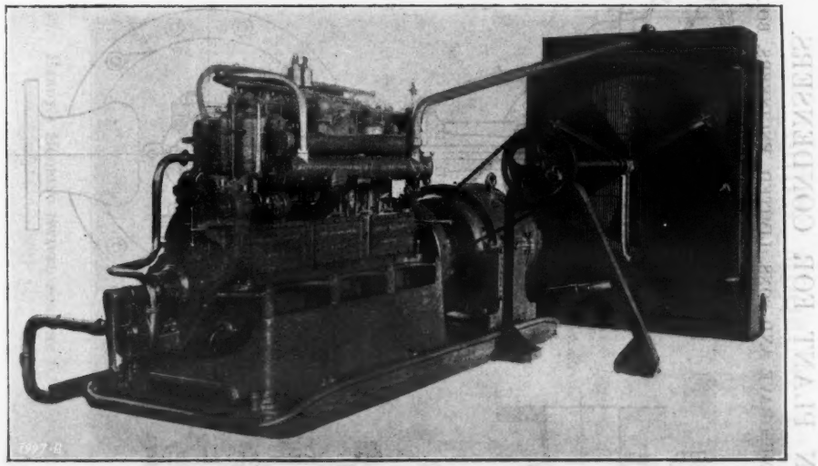


FIG. 7. EMERGENCY LIGHTING SET, WITH 75-B.H.P. PARAFFIN ENGINE; MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, BASINGSTOKE.

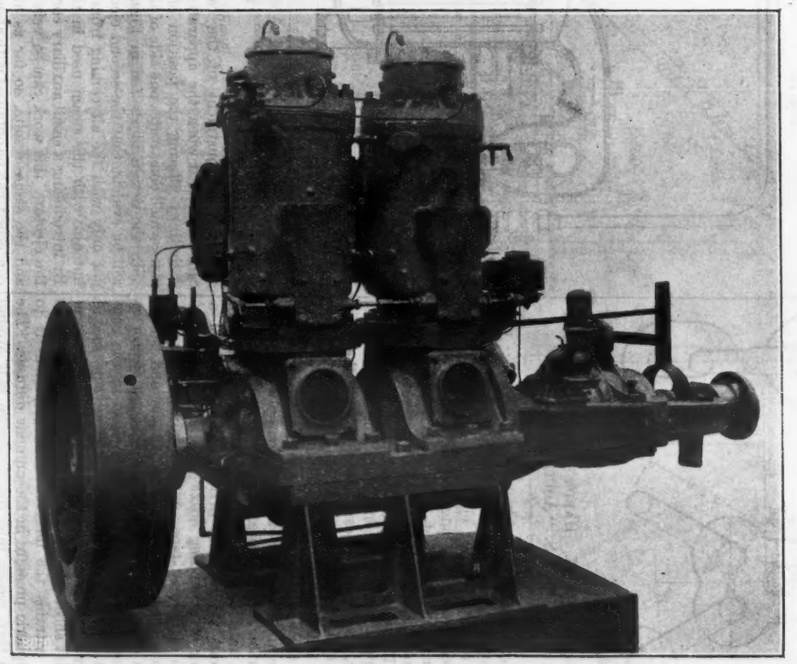


FIG. 8. 100-B.H.P. BRITISH KROMHOUT MARINE OIL ENGINE; MESSRS. PERMAN AND CO., LIMITED, LONDON.

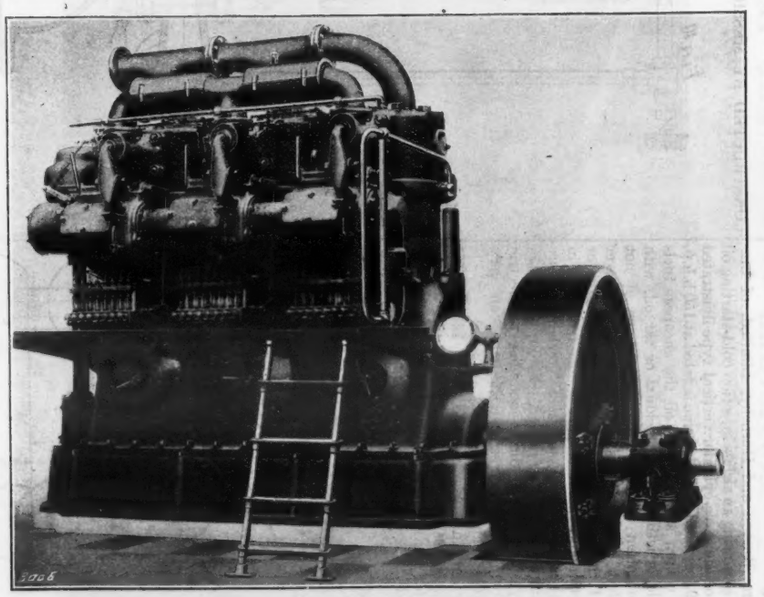
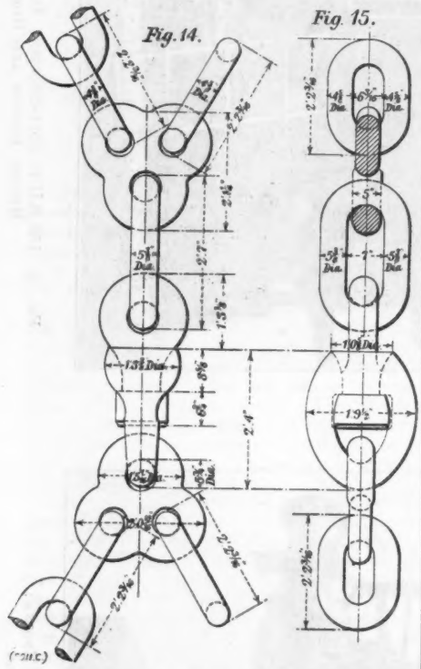


FIG. 9. 150-B.H.P. COLD-STARTING AIRLESS INJECTION HEAVY-OIL ENGINE; MESSRS. RUSTON AND HORNSBY, LIMITED, LINCOLN.

stationary or running, and the engine can be started from any position in the required direction of otation.

Messrs. Ruston and Hornsby, Limited, of Lincoln, are showing an airless injection cold-starting oil engine of the three-cylinder vertical type illustrated in Fig. 9, page 261. The engine is rated at 150 b.h.p. at 300 r.p.m., and will run on the cheapest fuels available, whether crude, residual or tar oil, with a consumption under working conditions of not more than ·43 lb. of oil per brake horse-power hour. It has no high pressure air compressor for oil injection and can be started at once from cold in all weathers without the use of a blowlamp or any other auxiliary heating device. The type is particularly suitable for direct coupling to electric generators, for which purpose it has been very successfully employed.

Messrs. John Musgrave and Sons, Limited, of the Globe Iron Works, Bolton, are exhibiting various steam jet air ejectors of the "Radojet" type, designed to replace the mechanical air pumps

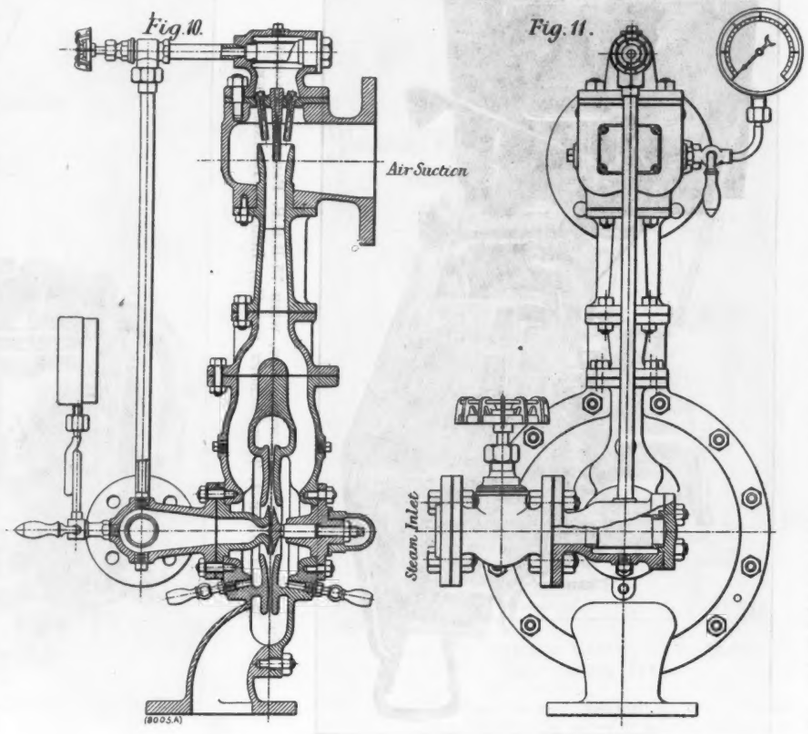


FIGS. 14 AND 15. HARDY'S MOORING SWIVEL FOR S.S. "AQUITANIA."

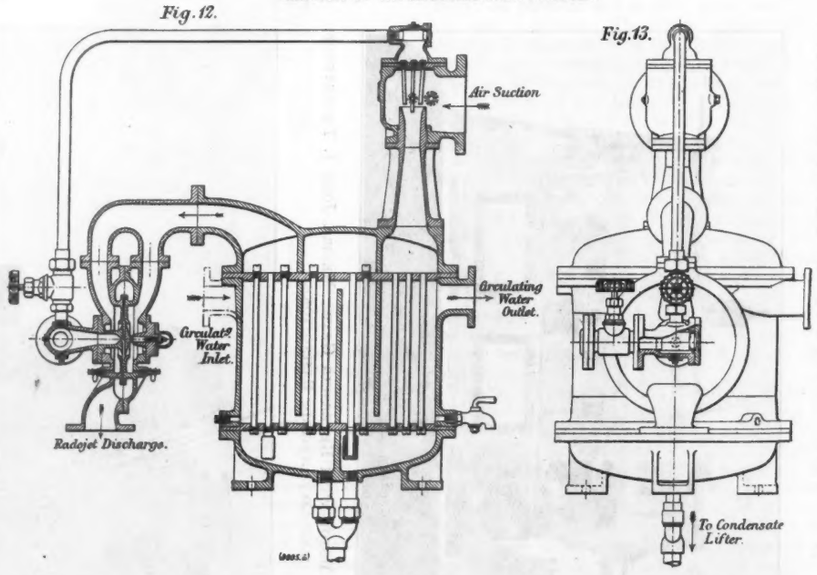
used to maintain the vacuum in condensers. Like most appliances of the kind, the "Radojet" apparatus consists of two ejectors working in series, its special feature being the radial-flow type of ejector used to effect the final delivery. The standard construction will be understood from Figs. 10 to 13, annexed. The air-inlet branch at the upper end is in communication with the condenser, and the live steam enters through the stop-valve and strainer shown in Fig. 11. Part of the steam is led to the first ejector by a small external pipe, the supply being independently controlled by the angle-valve shown. This supply is shut off at starting, the first ejector not being brought into action until the second ejector has created a vacuum of about 25 in. The first ejector consists of a number of expanding nozzles discharging into the mouth of a throat-pipe and entraining the air from the condenser. The mixture of air and steam passes down to the inlets of the second ejector at a pressure several inches above that in the condenser. The live steam operating the second ejector issues radially from its nozzle in the form of a flat sheet. The relatively large surface of this sheet entrains the mixture and compresses it to atmospheric pressure in the annular diffuser. The whole then passes into the discharge belt around the diffuser and escapes at atmospheric pressure through the branch pipe at the bottom of the

AIR EXTRACTION PLANT FOR CONDENSERS.

CONSTRUCTED BY MESSRS. JOHN MUSGRAVE AND SONS, LIMITED, ENGINEERS, BOLTON.



SECTION OF INTERCONDENSER RADOJET.



apparatus. Adjustment of the radial steam jet can be effected when the apparatus is working if desired by altering the position of the deflecting plate which constitutes one side of the nozzle.

In the design illustrated in Figs. 10 and 11, it will be evident that the second ejector has to deal not only with the air coming from the condenser, but also with the steam used in the first ejector. By introducing a small auxiliary condenser between the ejectors, this work can be very much reduced, and the same results, so far as air extraction is concerned, can be obtained with about half the steam consumption otherwise required. In Figs. 12 and 13 given above, this arrangement is illustrated. In the auxiliary condenser, the cooling water circulates round the tubes, through which the steam and air discharged from the first ejector make four passes. The condensate is returned to the main condenser. The radial-jet principle has also been applied to the design of a vacuum augmentor, for use in conjunction with the ordinary mechanical air pumps. The "Radojet" augmentor will operate with steam at from 2 lb. to 5 lb. gauge pressure, which is usually available from the auxiliary exhaust line.

Messrs. Brown Lenox and Co., Limited, of Pontypridd, Wales, whose name has been associated for generations with the manufacture of chains, anchors

SHIPS' MOORING TACKLE AT THE OLYMPIA EXHIBITION.

CONSTRUCTED BY MESSRS. BROWN, LENOX AND CO., LIMITED, ENGINEERS, PONTYPRIDD.

FIG. 16. HARDY'S MOORING SWIVEL FOR THE S.S. "AQUITANIA."

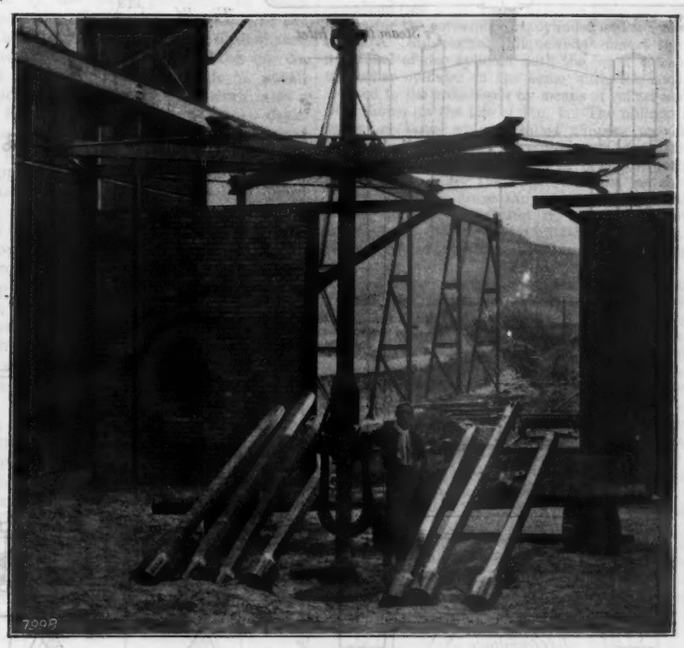


FIG. 17. CAPSTAN AND KEYS FOR FIXING MOORING SCREWS.

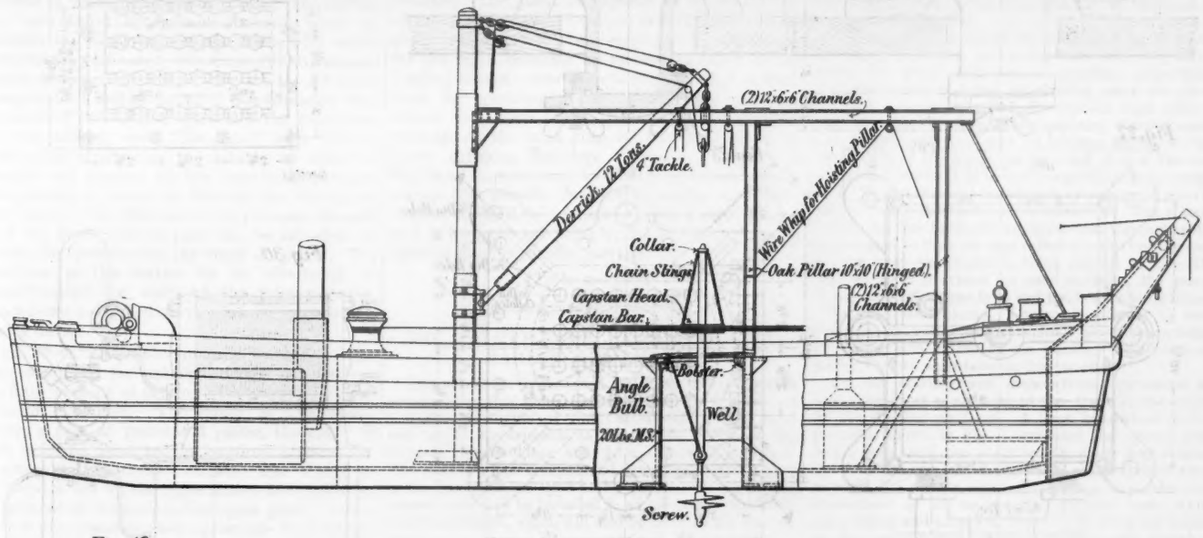
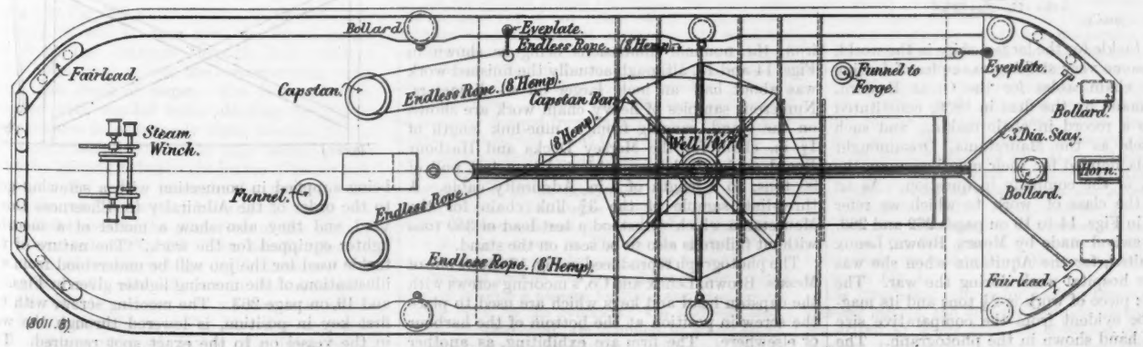


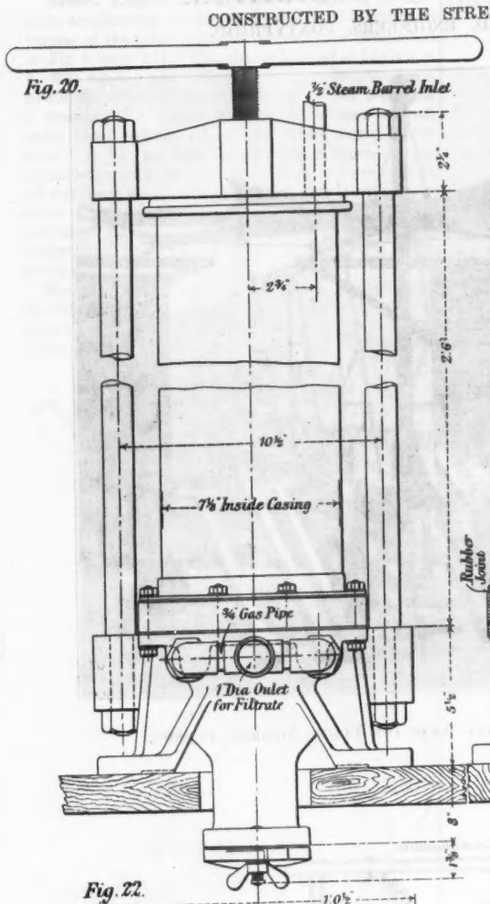
Fig. 19.

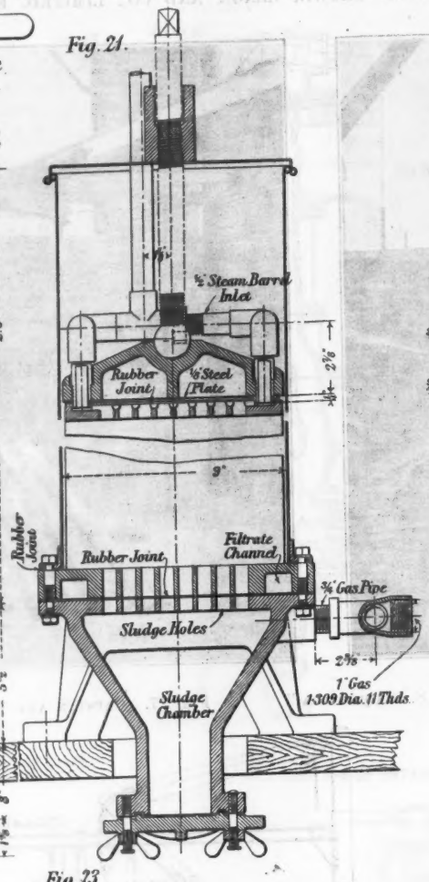


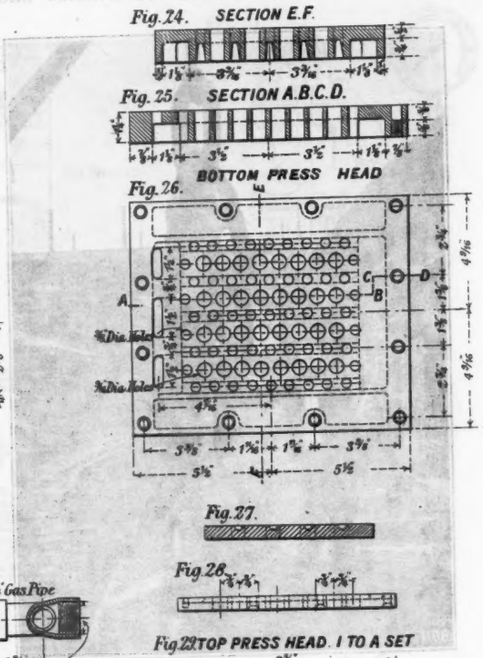
FIGS. 18 AND 19. LIGHTER EQUIPPED FOR FIXING MOORING SCREWS.

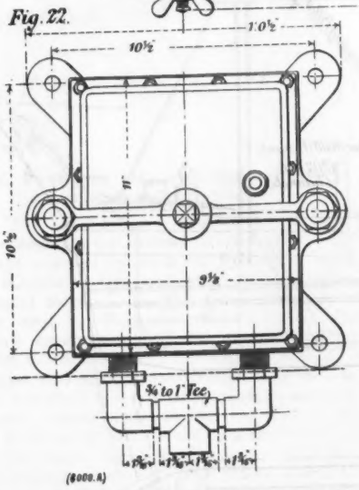
STREAM LINE FILTERS AT THE OLYMPIA EXHIBITION.

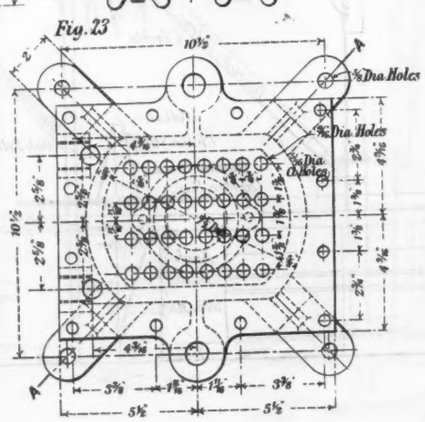
CONSTRUCTED BY THE STREAM LINE FILTER COMPANY, LIMITED, ENGINEERS, LONDON.

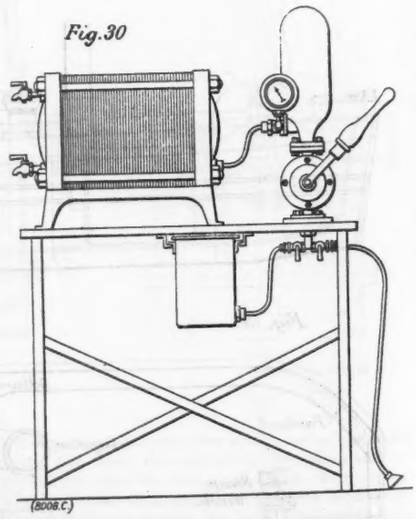












and mooring tackle for the largest ships in the world, are showing some very striking examples of forging work. The chain-cables for the Great Eastern, which were made by the firm in 1856, constituted at that time a record in chain-making, and such notable vessels as the Mauretania, Dreadnought and Aquitania depend for their moorings upon the forging work of the company in question. As an example of the class of work to which we refer we illustrate in Figs. 14 to 19 on pages 262 and 263, the mooring swivel made by Messrs. Brown, Lenox and Co., Limited, for the Aquitania when she was converted for hospital work during the war. The weight of this piece of work is 2½ tons and its magnitude will be evident from the comparative size of the man's hand shown in the photograph. The swivel and links were all forged from scrap wrought iron, the nominal dimensions being as shown in Figs. 14 and 15, although actually the finished work was about half an inch larger on all diameters. Numerous samples of heavy chain work are shown on the stand, ranging from a nine-link length of 1¾ in. chain for the Mersey Docks and Harbour Board, which had been subjected to a test pull of 90 tons, to a length of 4-in. Admiralty cable. A three-link sample of the 3¼ link chain for the Mauretania which withstood a test load of 350 tons without failure is also to be seen on the stand.

The photograph reproduced in Fig. 17 shows one of Messrs. Brown, Lenox and Co.'s mooring screws with the capstan head and keys which are used to place the screw in position at the bottom of the harbour or elsewhere. The firm are exhibiting, as another example of their forging, one of the actual keys being supplied in connection with a screwing gear to the order of the Admiralty for Sheerness Dockyard, and they also show a model of a mooring lighter equipped for the work. The nature of the tackle used for the job will be understood from the illustrations of the mooring lighter given in Figs. 18 and 19, on page 263. The mooring screw, with the first key in position, is lowered through the well in the vessel on to the exact spot required. The capstan head is then slung over the key as shown,

the key being free to move vertically within it. An endless hemp rope of 8 in. circumference is wound round the capstan head in such a manner that the leading-on and leading-off ends are diametrically opposite, so that the tension of the rope has no tendency to pull the capstan-head over. The rope is passed round guide pulleys and is driven by a deck-capstan, the result being that the capstan head is slowly rotated and the screw driven home. Successive keys are cottered in position as required, the number used, of course, depending upon the depth below the surface at which the screw is fixed. The whole of the keys are hoisted away together after the screw is in position. The stem of the mooring screw terminates in a square end, to suit the key by which it is driven, and the mooring chain is attached to a shackle which swivels on the neck of the stem. The capstan head which drives the screw is 20 ft. diameter and weighs about a ton and a half. The screwing keys, of which there are eight, are 15 ft. long, and weigh about 22 cwt. each.

The Stream Line Filter Company, Limited, of 64, Victoria-street, London, are showing various types of filters constructed on the principle invented by Dr. Hele-Shaw, which consists in forcing the liquid to be filtered between the surfaces of closely packed sheets of paper. The results obtained by this method are really extraordinary. Not only can grosser impurities such as suspended matter be abstracted from a liquid, but emulsions can be separated into their constituents and even liquids coloured by some substance in solution can be filtered clear and colourless. Moorland water, stained by peat, which has hitherto resisted every attempt to remove its colour by filtration, can be delivered in a perfectly colourless condition, and even more striking to the ordinary observer is the total removal of colour from a brilliant dye by its passage through the filter. The essential portion of the Stream Line filter consists of a stack of sheets of water-proof paper, pressed into contact with each other by suitable means. When so arranged, the numerous circular holes with which the sheets are perforated, coincide and form passages running from end to end of the stack. Of these passages about half the number communicate with the receiving end of the filter and the remainder with the delivery end. The liquid to be filtered is led under pressure to the interior of alternate passages and escapes by the remaining passages after passing between the faces of the waterproof paper sheets. The fineness of the passages through which the liquid has to pass can be adjusted by varying the pressure on the stack of paper. The impurities, or the matter to be eliminated, is retained round the walls of the inlet passages, whence it can be washed out or removed by a positive cleaning device.

Figs. 20 to 29, on the opposite page, show the arrangement and the principal details of a Stream Line filter capable of dealing with about 250 galls. of liquid per hour. The paper is compressed between a pair of perforated plates, the upper of which is forced down to the required pressure by the screw and handwheel shown. The liquid to be filtered is led by the pipes shown to a grid-iron arrangement of channels in the upper plate. These channels are closed on their upper side by a rubber joint backed by a thin steel plate and held in position by the pressure of the head-casting. Referring to Fig. 23, which illustrates the top plate separately, it will be seen that the liquid passes down from the channels through four rows of circular holes, and so into the corresponding holes through the stack of paper. The lower plate is perforated with similar holes allowing the liquid under pressure to pass freely right through to the closed sludge tank below. The only escape for the liquid is by passing between the leaves of paper into rows of smaller holes through the paper stack. The position of these outlet holes is shown by the smaller circles seen in the plan view of the bottom plate, illustrated in Fig. 26. The small holes in the bottom plate do not go right through, but communicate with channels cut in the underside, where the filtrate collects and whence it is withdrawn by the pipe shown in Fig. 21. The material filtered out is retained inside the inlet holes through the paper stack and can be washed out by opening the sludge chamber at the bottom.

For large filters an improvement on this method has been devised, whereby the holes are positively cleaned out by the passage of a small plug, driven through them by the water pressure. In many commerical processes the important product of the filter is not the filtrate, but the matter filtered out, and in the stream-line filter either or both can be recovered at will. The filter is made in small sizes for laboratory and experimental work, and a simple type, illustrated in Fig. 30, has been developed for household water supplies. On the stand is a model of a very large design in which hydraulic pressure is applied to the paper filtering material.

The Parsons Motor Company, Limited, of Town Quay Works, Southampton, exhibit a large range of engines for paraffin or petrol as fuel. Fig. 31, on page 370, shows a 60-b.h.p. standard marine engine designed to run on paraffin. The engine is fitted with metal to metal clutch and reversing gear.

In Fig. 32, on page 270, is illustrated a self-contained electric welding plant comprising a 14-b.h.p. petrol engine mounted on a portable bed which also carries a Metropolitan-Vickers generator, an exciter and a switch panel. The plant, which requires a single operator only, is complete with fuel-tank, radiator and silencer, and is suitable for lifting aboard a vessel or otherwise being brought to the place where the work is to be done.

Another portable plant, shown by the Parsons Motor Company, is illustrated in Fig. 33, on page 270. This plant consists of a 21-b.h.p. petrol engine fitted with Parsons reducing gear and clutch, and driving a single stage quad-ruplex Reavell air compressor. The compressor has a displacement of 106 cm. ft. per minute when running at 400 r.p.m., and delivers air at 100 lb. per square inch. The set is complete with fuel tank, radiator and pipe connectors, and is provided with roof and side curtains as a protection against weather. The plant is capable of operating two or three heavy paving-breakers or four light concrete picks, and several are now employed by contractors for the rapid breaking up of the road-beds of the London streets. Similar sets are employed in ship-yards for operating pneumatic rivetting hammers, chisels, &c. Four heavy rivetters can be supplied with air at the same time by the machine or six heavy chipping hammers. We also illustrate in Fig. 34 on the same page a 14-b.h.p. standard Parsons engine for paraffin fuel. The engine is direct-coupled to an E.C.C. generator with a rated output of 7·5 kw., the set being useful for an emergency lighting plant or similar purpose.

(To be continued.)

THE PALMER-CAMELLAIRD-FULLAGAR MARINE OIL ENGINE.

THE drawings reproduced on Plate XVIII, which accompanies this issue, illustrate the construction of a marine oil engine of the Camellaird-Fullagar type now under construction at the Jarrow works of the Palmers' Shipbuilding and Iron Company, Limited. This engine, which is capable of developing 3,000 b.h.p., is the largest of its type to be constructed up to the present, and will be installed in an oil tanker of 10,000 tons deadweight, which will also be built at the Jarrow yard.

The principles involved in the design of this engine and the advantages arising therefrom, were fully dealt with on page 144 of our 109th volume, and are now doubtless familiar to most engineers. Its reliability has since been fully demonstrated by the performance of the engine fitted in the motor ship Malia, of which installation full particulars will be found on page 503 of ENGINEERING, volume 112. Further evidence of this has been derived from numerous test-bed trials of different sizes carried out at the works of licensees.

The engine illustrated embodies the latest improvements in design, and, as will be seen from Fig. 1, has six cylinders of 23 in. bore, each provided with two opposed pistons. The stroke of each piston is 36 in., and the above-mentioned power will be developed at 90 r.p.m. As shown in Fig. 1, the cylinders are arranged in pairs with distance pieces between them at the top and bottom, the lower distance pieces being utilised to provide a passage for the scavenge air to the scavenge belts on the cylinders; the scavenge belts, it should be mentioned, are common to all cylinders. The cylinder liners are of special design and are constructed of cast-iron reinforced with steel bands in the neighbourhood of the combustion space. In this portion of the liner the cooling water is arranged to circulate between the bands and the liner to ensure efficient cooling. Cast steel is used for the pistons and also for the upper and lower crossheads. Each upper crosshead (see Figs. 1 and 2) forms the scavenge pump piston for the corresponding cylinder and is rectangular in shape. Substantial oblique rods connect the upper crosshead of one cylinder with the lower crosshead of the other cylinder in the same unit, the rods being secured to the crossheads by means of collars and nuts, best shown on the left of Fig. 1. The oblique load is taken on large white-metalled slippers provided on both upper and lower crossheads. The centre plate between the scavenge pumps of one unit forms the rubbing surface for the upper slippers, as shown in Fig. 1, while the lower slippers work on special faces formed on the forward and aft sides of the columns, as will be clear from an examination of Fig. 2. The pressure intensity on these working surfaces is extremely low.

The scavenge pumps are built up of cast-iron centre, end and side plates, so arranged that by taking off the end plates, the upper crossheads and pistons can be easily removed. The suction and discharge valves are fitted in the covers of the scavenge pumps, the air being drawn in through perforated plates on the sides and the covers being connected by branch pieces on the discharge side. These branch pieces, it will be noticed, form distance pieces connecting the cylinder units, and thus prevent vibration. The discharge is led down by pipes from the branch pieces to the lower cylinder distance pieces and thence into the scavenge belts, as previously mentioned.

The crankshaft consists of three interchangeable sections, each forged from the solid, with a separate forging at the forward end for the compressor crank. The bedplate, which is closed at the bottom to form a well for oil, is also made in three sections for the main engine and one for the compressor. The latter supplies the injection air, and is of the four-stage type. Each compressor cylinder is provided with a renewable liner, those for the third and fourth stages being steel forgings of special quality. Cast-iron columns bolted to the bedplate carry the cylinders of the main engine, there being one column at the front and one at the back for each pair of cylinders.

The camshaft is driven by spiral and bevel gearing as shown in Fig. 1, and is provided with two sets of cams for ahead and astern running, respectively. One fuel valve and one air-starting valve are placed on each cylinder diametrically opposite each other as shown in Fig. 2. The levers operating the fuel valves are eccentrically mounted on fulcrum shafts, so that the rollers on the levers can be lifted clear of the cams when the camshaft is moved longitudinally for reversing. This movement is effected by means of a servo-motor clearly shown in both illustrations. The starting valves are mechanically operated and the mechanism is arranged so that the cam rollers are clear of the cams except when the engine is being started on air. One fuel pump is provided for each cylinder, the pumps being of the glandless type and the bodies being formed from solid steel blocks. Control is effected by hand and also by means of an Aspinall governor operating on the suction valves of the pumps. The latter are driven by two eccentrics on the camshaft.

All the starting and manœuvring operations are controlled from a pedestal at the front of the engine on the starting platform. A large handwheel on this pedestal, shown in Fig. 1, operates the control shaft which runs along the whole length of the engine below the level of the camshaft. The control shaft turns through 165 deg. in either direction and, at the commencement of its movement, operates cams which open valves and admit air from the starting-air bottles to the servo-motor, thereby moving the camshaft longitudinally so as to bring the correct set of cams into action. During this period, the fuel and starting-air cam rollers are kept clear of their respective cams by means of another set of cams, but further movement of the control shaft brings the starting-air valves into operation and allows the fuel-cam rollers to engage with their cams in the proper sequence. An eccentric on the control shaft, acting on cams on the suction valves of the fuel pumps, then allows the latter to deliver oil to the fuel valves in pairs, after the engine has been set in motion by air. It should also be mentioned that, at an earlier period of the movement of the control shaft, an eccentric on the latter operates the air-injection valve which controls the admission of blast air. The opening of the fuel valves and the setting of the fuel pumps are controlled by separate handwheels on each side of the main handwheel, as shown in Fig. 1.

The circulating pumps for cooling the pistons and cylinder jackets, and also the forced-lubrication pump, are driven by levers from the crosshead of the compressor; fresh water is used for cooling both pistons

and cylinders. It should also be mentioned that, when the engine is installed, arrangements will be made so that the exhaust gases can be either passed through the furnaces of a cylindrical boiler or led directly through the silencer to the funnel. The steam raised in the boiler by the waste heat from the gases will be sufficient to supply the requirements of the vessel for cooking and heating accommodation, and also for heating the fuel oil.

The particular advantages claimed by the makers for the type of engine described above are the simplicity and economy which arise from the absence of cylinder covers and from the position of the camshaft in front of the cylinders in close proximity to the fuel valves. The use of long push rods is, of course, avoided by this feature, which also allows the cylinders to be examined internally without disturbing the camshaft gear. As previously mentioned, access to the upper crossheads and pistons can be obtained by removing the end plates of the scavenge pumps, while the lower crossheads are equally accessible. The engine is also claimed to occupy less space and to have a lower weight for a given power than most other types of marine oil engines available. Simplicity in starting and reversing are other points in its favour, since all the necessary operations for manœuvring can be carried out in a few seconds by one engineer. [Work on the engine illustrated is now well advanced, and we hope to give particulars of test-bed trials at a later date.

3-FT. 9-IN. PORTABLE UNIVERSAL DRILLING MACHINE.

The annexed illustration is reproduced from a photograph of one of a class of drilling machines which Messrs. William Asquith (1920), Limited, of Halifax, make a speciality. The machine has been considerably modified from its earlier forms and its versatility enhanced. As now designed and constructed it is a machine of very wide adaptability and a very serviceable tool. The general features are evident from the view given.

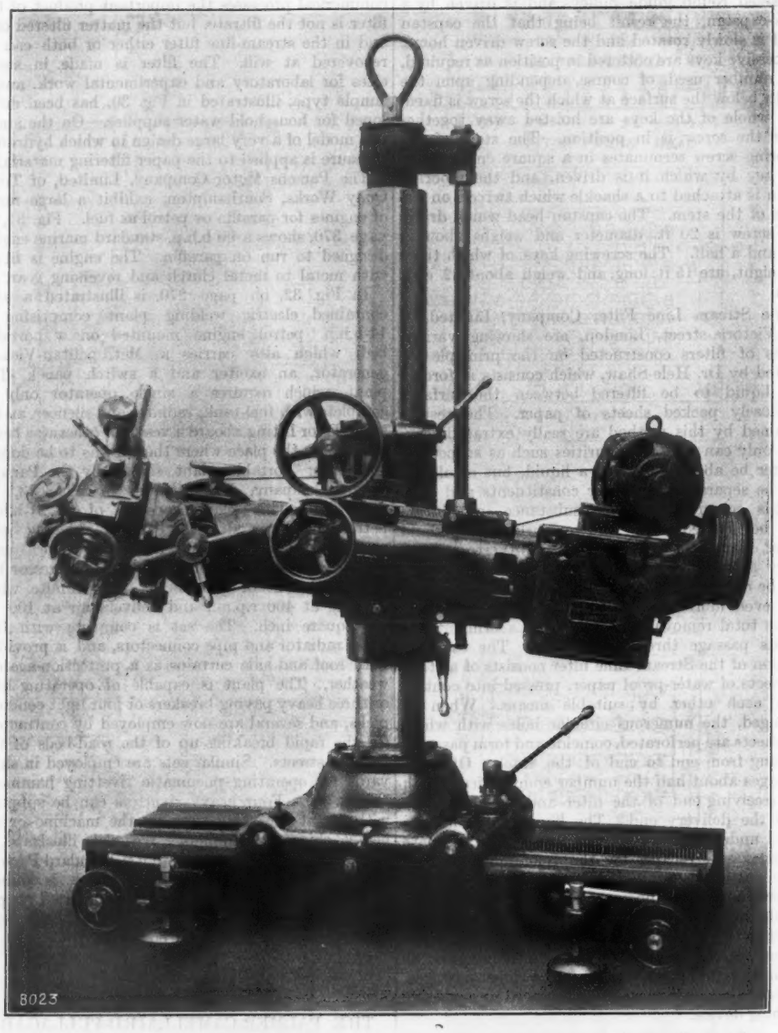
The base is a long casting fitted with trolley wheels and with side lugs for four adjustable feet which are screwed hard down on the floor when drilling. The upper part of the bed is finished with ways for a saddle and with an internal rack. The column is carried by a large saddle running on rollers on the ways just mentioned, and is traversed by a pinion worked by a ratchet handle which can be seen extending upwards in a slanting direction. This handle is swivelled and can be lowered or raised to any convenient position. The saddle is locked in position by the small handle in the centre of its side, below the machined slide. The column supports a sleeve which carries the drilling arm. The sleeve is raised or lowered by means of a nut working on the long screw hanging from the column head, at which point ball bearings are fitted to make radial adjustment easy. The sleeve can be locked when the desired position has been obtained, by the large handle seen projecting past the screw. The arm carrying the drilling head and the motor, &c., can be tilted up or down through 30 deg., or can be run in or out. The former motion is accomplished by the large hand wheel close to the column, while the traverse in or out is secured by the smaller wheel below.

The arm actually consists of a frame formed of two main side members, of which one is arranged on each side of the column. At the rear end the side pieces are joined by a casting carrying the driving motor. At the drilling end the gap is filled by a casting carrying the drilling head and pivoted on the centre of the capstan handle shown. This arrangement enables the whole head to be swivelled, and as the head also swivels on the casting, the spindle itself is provided with universal movement and can be set to drill in practically any direction—vertically, horizontally or to almost any combination of angles. The head is swivelled on the arm by means of a ratchet, the capstan handles providing for the hand traverse in and out of the arm. The drive is by electric motor on the tail of the arm where a cable reel is also arranged, as well as the starting panel, the latest model, however, having a panel not quite the same as that shown and fitting rather more compactly along the side of the arm. The drive to the head is by belt. The whole machine can be easily transported by a crane by means of the stout eye at the head of the column. The particular size of machine illustrated is one of 3 ft. 9 in. maximum radius, the minimum distance being 2 ft. 4 in. The maximum height from the floor to the spindle when vertical drilling is 5 ft. and the minimum 2 ft. When drilling horizontally the range is between 7 ft. and 1 ft. 3 in. from the floor to spindle. The diameter of the column is 9 in. and the traverse on the base is 4 ft. The spindle is 2 in. in diameter and has a feed traverse of 1 ft. 6 in. either by hand or self-acting. Two feeds are provided, namely, 160 cuts per inch and 260 cuts per inch. The necessary reversing motion is provided. The number of speeds obtainable is six, and the range is from 300 r.p.m. to 41 r.p.m. by means of change gears in the head, controlled by the small hand wheel shown above the capstan handles. Several sizes of machines of this class are made up to one with a 7 ft. maximum radius, drilling horizontally up to 9 ft. above floor, and having four feeds and eight spindle speeds.

Machines of the type can well lay claim to the designation universal. They can be moved about a works to speed up ordinary drilling operations. They can be placed on large castings on an assembling floor for drilling bolt holes. They can deal with angle drilling without packing the work in awkward positions, and can even drill vertically upwards if necessary. There are few holes within their range that they cannot reach, and they result in much better work than do the ordinary methods adopted with awkward jobs.

3-FT. 9-IN. PORTABLE UNIVERSAL DRILLING MACHINE.

CONSTRUCTED BY MESSRS. WILLIAM ASQUITH (1920), LIMITED, ENGINEERS, HALIFAX.



TRIALS OF A TURBO-GENERATOR AT THE DALMARNOCK POWER STATION.

We are indebted to Mr. R. B. Mitchell, Electrical Engineer to the Glasgow Corporation, for a copy of his report describing tests made last January of the large turbo-generator supplied to the Dalmarnock power station by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester. The trials are of special interest as the turbine, illustrated in Engineering, vol. cxi, page 451, embodied Mr. Baumann's "multiple exhaust," and we comment on the results elsewhere in this issue. Mr. Mitchell's report is as follows :—

Steam Consumption Test on 18,750-kw. Turbo-Alternator Set at Dalmarnock Power Station.

The Dalmarnock Power Station of the Glasgow Corporation Electricity Department is a typical example of a power station having a good supply of low temperature cooling water. The tests of a turbo-alternator unit working under Dalmarnock conditions may, therefore, be of interest to many power station engineers. The first section of the station is laid out for, and has installed, five generating sets, and the figures published are for No. 3 machine, which is manufactured and supplied by the Metropolitan-Vickers Company, Limited. The main particulars of the set tested are as follows :—

Turbine.—This is of the single-cylinder impulse type fitted with the Metropolitan-Vickers multi-exhaust blading. The feed heater formed in the lower half of the turbine casing enables feed heating to be carried out on the Metropolitan-Vickers patent system. Steam from a pressure stage corresponding to about 22 in. vacuum surrounds the feed heater tubes through which the main condensate passes on its way to the hot well. The mean diameter of the turbine blading is 7 ft. and the equivalent length of the last row of blades through the use of the multi-exhaust blading is 3 ft. By this means exhaust losses are reduced to a very low figure.

Condenser.—The condenser is bolted direct to the turbine exhaust end and has a tube area of 26,000 sq. ft. Circulating water is taken through screens from

the River Clyde and is then led in to the station through a concrete duct. The circulating pump is submerged and is driven by a vertical spindle, three-phase motor. The condenser discharge is led to a similar duct on the other side of the station. The air is extracted from the condenser by a motor-driven Le Blanc air pump running at 1,440 r.p.m. The condensate pump is driven by the same motor in line with the air pump.

Alternator.—The alternator is directly connected to the turbine and runs at 1,500 r.p.m. The voltage at the alternator terminals is 6,500 and the periodicity 25 cycles per second. The alternator is directly connected to a bank of three single-phase "Delta" star connected transformers which raise the voltage to 20,000 volts. The cooling air for the alternator is delivered through fans mounted on the rotor shaft. The quantity of air supplied is 70,000 cubic ft. per minute at 6 in. water gauge. The set is designed for a maximum continuous rating of 18,750 kw. 23,400 kva., the most economical load being 15,000 kw. The maximum overload capacity is 21,000 kw.

The test referred to was carried out after the set had generated 42,195,400 kw. hours, the machine having been put into commission for the first time on November 9, 1921.

The guaranteed steam conditions at the stop valve were—

Pressure—250 lbs. per square inch (gauge).
Temperature—650 deg. F.
Vacuum—29·1 in. mercury.

The guaranteed steam consumptions of the set were as follows:—

At 18,750 kw.—10·32 lbs. per kilowatt hour.
15,000 kw.—10·32 lbs. per kilowatt hour.
11,250 kw.—10·92 lbs. per kilowatt hour.

The average steam consumption was guaranteed to be 10·44 lbs./kilowatt hour. The average steam consumption was calculated as follows:—

Average consumption = 1/10th the sum of three times the consumption at 18,750 kw., five times the consumption at 15,000 kw. and twice the consumption at 11,250 kw.

The test results are summarised below:—

Test of January 11, 1923.

Nominal load—kw.	18,750	15,000	11,250
Duration of test—hrs.	1·718	2·14	1·0018
Approx. load at alt. terms—kw. ..	18,200	15,650	11,800
Actual conditions—			
S.V. press. lbs./sq. in. g. ..	250	254	254
S.V. temp. degs. F.	643	618	610
Vac. 30 in. bar. inches hg. ..	29·25	29·31	29·34
Cons. as run—lbs./kw. hr. (power measured at alt. terms)	10·222	10·248	10·374
Cons. corrected to design condns. (power measured at alt. terms) ..	10·293	10·207	10·333
Cons. correctd. to design condns. (power measrd. at h.t. side of transf.)	10·398	10·303	10·421
Average consumption lbs./kw. hr...	—	10·355	—

Every precaution was taken to ensure the accuracy of the test results, and the electrical instruments used were calibrated before and after the test by the Manchester School of Technology. The mean of the calibrations were used in calculating the test results. A check test was made on January 13, 1923, and the average consumption was found to be within one-third per cent. of the official test results as given above.

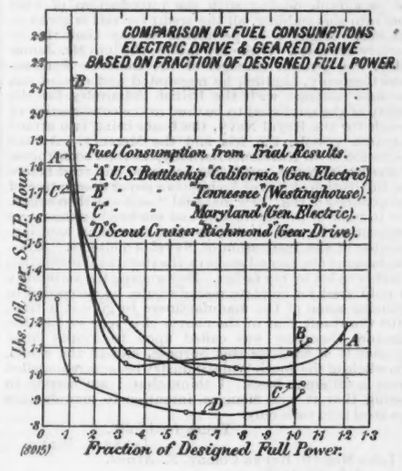
ELECTRICAL PROPULSION OF SHIPS.

IN reference to the recent discussion on the results obtained with the electrical system of reducing the speed of running of marine turbines to those suitable for efficient working of the propellers, we have received the annexed communication from Mr. J. F. Metten, chief engineer of the William Cramp and Sons Ship and Engine Building Company of Philadelphia, U.S.A.

A paper by W. L. Emmet on "Electric Ship Propulsion" was read at the Spring Meeting of the Institution of Naval Architects. The discussion of the paper by members of the Institution was printed in the March 30, 1923, number of ENGINEERING, and should be read by everyone interested in this subject, as it presents a sound statement of essential factors that have controlled the development of propelling machinery for war vessels and merchantmen from the advent of steam to the present day. It is a significant fact that the views expressed in the discussion of the paper by the British Engineers are also in accord with the opinions held by the engineering heads of the first-class United States shipyards, all of whom have had to deal with the designs of propelling machinery for all classes of naval and merchant work for many years.

The discussion of this paper, in substance, pointed to the facts:—(1) that the weight and cost of electric drive machinery are admitted by its advocates to be considerably greater than for geared turbine installations; (2) that the electrical losses of the electric reduction are also admitted by its advocates to be greater than the mechanical losses of the gear reduction; (3) that the conditions imposed upon turbine design by the adoption of gear drive do not prevent the attainment of practically the same water rates per shaft horse-power as can be obtained from turbines driving electric generators; (4) that there has never been shown in practice any gain in economy, therefore the increased weight of the electric drive means that the vessel equipped with this drive must be either of greater displacement, with a correspondingly greater demand upon the fuel necessary to transport itself, or it must carry less offensive and defensive armament in the case of a naval vessel, and less cargo, &c., in a merchantman; (5) that the reliability of properly built geared turbine machinery leaves nothing to be desired, and such machinery requires no specialists for its operation.

On the question of economy the members of the Institution contributing to the discussion showed no uncertainty in their views, which can be understood when it is remembered that the performance of our electric drive battleships has been well known in England, where for a number of years vessels of a similar type fitted with modern geared turbine machinery have been in service, the performance of which has been the basis of comparison with the American electric drive capital ships. In the United States the advocates of electric drive have been comparing the performance of modern electric drive machinery with the performance of direct drive turbine machinery and reciprocating engines in capital ships, and this method of comparison for publicity purposes can be traced back to the advent of the electric drive collier Jupiter, which Mr. Emmet again states in his paper to have shown "much better fuel economy than the sister ships Cyclops and Neptune, one of which was driven by reciprocating engines and one by Parsons turbines." Similar statements have


COMPARISON OF FUEL CONSUMPTIONS
ELECTRIC DRIVE & GEARED DRIVE
BASED ON FRACTION OF DESIGNED FULL POWER.
Fuel Consumption from Trial Results.
'A' U.S.Battleship 'California' (Gen. Electric).
'B' - - 'Tennessee' (Westinghouse).
'C' - - 'Maryland' (Gen. Electric).
'D' Scout Cruiser Richmond (Gear Drive).
Lbs. Oil per S.H.P. Hour.
Fraction of Designed Full Power.
(8915)

appeared so many times that it seems opportune to give a few facts relating to the performance of these ships.

The Cyclops was delivered about three years before the Jupiter, and her machinery was a standard merchant triple installation operating with saturated steam at a boiler pressure of 190 lbs. Each vessel was given a 48-hours trial at load draft by a Naval Trial Board, the fuel used being accurately weighed. When the

TABLE I.—*Comparison of Trials. U.S. Colliers "Cyclops" and "Jupiter."*

	Cyclops.		Jupiter.
Number of screws	2		2
Type of machinery	Triple expansion		Turbine electric
Date of trial trip	October, 1910		February, 1914
Duration of trial—hours ..	48	From standardisation	48
Displacement—tons ..	19,095	19,146	19,452
Speed in knots	14·61	14·99	14·99
Indicated horse-power ..	6,705	7,060	—
Shaft horse-power	—	—	7,152
Revolutions per minute ..	92·26	94·60	116·72
Effective horse-power—bare hull	3,950	4,275	4,310
Coal burned per i.h.p. per hour—lbs.	1·4846	1·485*	—
Coal burned per s.h.p. per hour—lbs.	—	—	1·662
Coal burned per e.h.p. per hour—lbs.	2·52	2·45	2·77
Coal burned, tons per 24 hours	106·5	112·4	127·4
Knots per ton of coal ..	3·3	3·2	2·82
Knots per ton of coal—corrected for same displacement	—	3·2	2·88

Cyclops on 5 high runs of standardisation averaged 15·485 knots, developing 8,057 i.h.p. at 97·97 r.p.m.
On 48-hour run, 12 hours were run in head gale and high sea.
* Assumed same as on 48-hour run.

Jupiter completed her trials it was found that on a strictly fair comparison of results the consumption of the Jupiter in weight of fuel per knot run was 10 per cent. greater than the Cyclops' consumption at the same speed and displacement. This is a matter of official record, and can be checked from Trial Board reports.

The essential data from these trials is shown in Table I, the first and last columns being trial figures, the middle column giving the corrections made for difference in speed and displacement based upon standardisation and model tank curves. These trial figures, however, did not please the electric drive advocates who, by "conservative assumption" of engine mechanical efficiency, steam used by auxiliaries, and other factors not measured on the Cyclops' trial, made up a comparison that showed that the coal per shaft horse-power of the Cyclops was greater than on the Jupiter. The fact that the Jupiter burnt more fuel to transport the same displacement a given distance was never mentioned, and evidently considered to be of no consequence. Further, the statement made in Mr. Emmet's paper that the Neptune was fitted with Parsons turbines is not correct. The turbines were a polyglot combination of impulse and underbladed reaction elements, for which the Parsons Company were in no way responsible. Had the Neptune been fitted with a standard Parsons geared installation she would have worried the electric drive advocates more than did the Cyclops.

Mr. Emmet referred also in his paper to the 2,000,000 s.h.p. of reduction gears produced under his direction, from which he has apparently obtained the data showing such extremely poor efficiencies for the gear drive, and operating experience with which probably accounts for his pessimistic views on the reliability of gearing in general. This attitude is to be expected under the circumstances, as the troubles experienced with this gearing in the merchant service is generally known, and must have imposed a heavy burden upon the builders. However, there are other manufacturers of reduction gearing who have been able to obtain much higher efficiencies, and whose gears have been entirely free from trouble. The firm with whom the writer is associated has built and installed geared turbine machinery also aggregating approximately 2,000,000 s.h.p. in all sizes up to 22,500 s.h.p. per unit, and there has not been a replacement of a pinion or gear on any of this machinery since it was delivered. Several of the merchant vessels have steamed well over the 500,000 mile mark, with gearing still in perfect condition.

In Mr. Coulson's reply to the discussion for the author, reference was made to merchant ships that have had gear drives removed and replaced by electric drive machinery, which presumably refers to the United States Shipping Board freighters Eclipse, Independence, Archer, Victorious, &c. As a result of the attractive claims put forward by electric drive advocates, and predicated on optimistic curves showing how a horse-power could be obtained on extremely low fuel consumption for all purposes, the Shipping Board started on an electric drive conversion programme for 12 of their ships. However, the first to be completed, the Eclipse, fell so far short of fulfilling these promises that the programme was curtailed to those for which the new machinery had been practically completed.

TABLE II.—*Performance of Electric Driven Ships with General Electric Equipments.*

Route.	Eclipse. (A) Savannah to Otaru via Panama and Honolulu.	Independence (B) Balboa to Yokohama via Honolulu.	Archer. (C) New York to Yokohama via Panama and Honolulu.	Victorious. (D) Cristobal to Yokohama via Honolulu.	Total & Means. (A) (B) (C) (D) —
Mean draft ..	28′ 8″	24′ 10½″	28′ 8″	28′ 3″	27′ 8″
Mean displacements—tons	15,950	13,748	15,665	15,605	15,450
Total hours (bar to bar) ..	1062·25	787·61	1014·9	820·7	3685·0
Total distance—nautical miles	9,894	8,235	10,314	8,081	36,526
Mean speed in knots ..	9·31	10·58	10·17	9·85	9·92
Mean shaft horse-power ..	2,224	2,365	2,766	2,200	2,396
Fuel cons. at sea—tons ..	1,363	1,143	1,456·4	1,150	5,112
Fuel cons. at sea—tons 24 hrs. ..	30·8	34·87	34·5	33·6	33·3
Mean revs. per minute ..	88	96·4	92·4	87·2	90·8
Mean lbs. oil per s.h.p. hr.	1·292	1·375	1·165	1·427	1·297
Boiler pres. lbs. per sq. in. gauge ..	210	205	—	—	—
Superheat —deg. F. ..	195	195	—	—	—
Vacuum—ins.	27·5	28	—	—	—
Miles per ton of fuel	7·26	7·20	7·08	7·03	7·15
Lbs. of fuel per mile	309	311	316	319	313

A summary of the actual performance of these vessels from the operating logs is given herewith, Table II, which shows them to be using at least 30 per cent. more fuel than the geared installations on similar ships. Moreover, these electric drive installations were given the advantage of high superheat, and a comparison of the operators' logs before conversion with the author's type of geared machinery originally installed, and after conversion, show that the money spent in removing the geared turbines and installing the electric drive

resulted in increasing the total fuel consumption 10 per cent. It would be most interesting to compare the original guarantees of the builders of these same electric drive installations with these actual performances here shown, in view of their claims for the accuracy with which predictions of electric drive performances have been fulfilled in practice. In this connection it is well known that the guarantees for water consumptions were not met on the New Mexico, which was the first battleship fitted with electric drive.

The paper gives an example of "conservative assumptions" in the 32-knot cruiser, which Mr. Emmet states with a geared turbine installation could not do better than 1·27 lbs. of oil per shaft horse-power with saturated steam when running at 19 knots. This speed requires approximately 13 per cent. of the power necessary for 32 knots, and by referring to the actual performance curve of the cruiser Richmond, driven by Parsons turbines through single reduction gears, with saturated steam, it will be noted that her actual consumption at 13 per cent. of full power was 0·98 lbs. per shaft horse-power for all purposes. Mr. Emmet's justification for the 535 tons additional weight of the electric drive Scout machinery, upon the claims that a geared drive installation could not do better than 1·27 lbs. per shaft horse-power for all purposes, therefore fails to be substantiated. Referring further to the fuel consumption of the Richmond, it will be noted that the fuel for all purposes at from 50 per cent. to 80 per cent. of full power was under 0·86 lb. per shaft horse-power hour, the slightly increased consumption at full power being due principally to the high rates of combustion, and correspondingly lower boiler efficiencies under the condition when there was being developed slightly over one shaft horse-power for each square foot of boiler heating surface and for each ½ sq. ft. of condenser cooling surface. The Richmond's consumption figures were obtained by calibrated apparatus throughout, results being checked by two sets of observers, one of which represented the Navy and one the contractors. Under similar test conditions the best that has been shown with the electric drive installations has nowhere approached these figures. At 13 per cent. of full power the electric drive machinery shows a consumption of over 1½ lbs. per shaft horse-power, compared with 0·98 lbs. for the Richmond's geared turbine machinery. It is a far cry from 1½ lbs. per shaft horse-power to 0·85 lbs. per shaft horse-power for all purposes, and this latter consumption under full power conditions even seems a long way from attainment on any accredited electric drive records. This possibly explains why the results of the electric driven battleship were not included in Mr. Emmet's paper, the absence of which was pertinently commented upon in the discussion.

The consumption curves for the passenger ship, based upon the consumption of the Japanese ship Kamoi obtained by "tests between New York and Honolulu" cannot be considered very seriously in the absence of any explanation as to how the Kamoi test was conducted, or how the dotted portion of her curve below the 1 lb. ordinate was obtained.

(See Fig. 7, reproduced from Mr. Emmet's paper, ENGINEERING, vol. cxv, page 416.)

CITY AND GUILDS OF LONDON INSTITUTE.—The programme for the 1923–1924 session of the Department of Technology at this Institute, 29, Roland Gardens, South Kensington, S.W.7, is published by Mr. John Murray, Albemarle-street, W.1, at the price of 3*s.* 6*d.* net. This programme covers a very large number of subjects and classes, dealing with a great variety of industries and trades; it may be studied with advantage by young men desirous of improving their technical knowledge. All enquiries should be addressed to the Superintendent of the Department, at the above address.

THE LATE MRS. HERTHA AYRTON.—The Institution of Electrical Engineers has lost its only lady member, Mrs. Hertha Ayrton, who, though living in comparative retirement of late at North Lancing, Sussex, where she died on August 26, continued to take an active interest in the proceedings of the Institution. As late as last December, in fact, she opened the discussion of a paper on "Electric Arc Welding," which Mr. J. Caldwell brought before the Institution, as we mentioned on page 776 of our issue of December 22, 1922. Mrs. Ayrton was a daughter of Mr. Levi Marks and was born at Portsea. Educated at a private school and at Girton College, Cambridge, she became a research student at the Central Technical College, South Kensington, under Professor Ayrton, whom she married in 1885. Her husband died in 1908. She made the study of the electric arc her speciality. During and after Professor Ayrton's absence in America she worked independently; her various papers on the arc, its laws and peculiarities, contributed to the Institution of Electrical Engineers, the British Association, the Royal Society and other bodies, and to the columns of the *Electrician* established her as an authority on that subject. Her book on the "Electric Arc" appeared in 1902. The Royal Society nominated her for Fellowship in 1902, but the Charter of the Society did not admit of the election of women. The Royal Society, however, awarded her the Hughes medal in 1906. Her experimental studies of the formation of sand ripples on the sea shore also made her widely known, as did subsequently her active advocacy of women's rights. She invented a line divider, and later, during the war, an anti-gas fan (flapper), which was adopted after long delay, in April, 1916; over 100,000 of these fans were finally used at the front. The cremation took place at Golders Green yesterday, without any ceremony by her request; Sir James Dewar had made the same request in his will.

DANGEROUS VOLTAGES.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the letter of "J. L. R. P." in your current issue I may perhaps be permitted to cite a case coming under my personal experience in which a pressure of eight volts only was sufficient to cause considerable discomfort. Current was being taken from an eight volt plating dynamo by temporary cables to a pickling vat outside the building, one cable being connected to some iron strip from which it was required to remove the scale, and the other to a carbon electrode. The ground was "made ground" of ashes and cinders, and was saturated with water by continuous rain. With one's boots throughly wet, as they soon became, it was impossible to handle the work submerged in the warm acid bath without being very unpleasantly aware of the voltage, so much so, indeed, that a dry plank had to be obtained to stand on. The effect was felt by several others besides the writer. There was no question of the voltage at the machine terminals, which was checked by a voltmeter, and there was no possible connection with any other circuit.

Yours faithfully,
August 25, 1923. R. H. P.

"THE CENTENARY OF SIR WILLIAM SIEMENS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your paper of March 30 last you published an article, The Centenary of Sir William Siemens, which I read with great interest, more especially as my father was so closely associated with him. With reference to the paragraph dealing with the introduction of mild steel into shipbuilding, all the credit for this is given to Siemens. Might I be permitted to say that this is scarcely accurate. While my father, the late Mr. James Riley, was general manager of the Landore Siemens-Steel Company, Limited, he negotiated and carried out the first contract with the British Admiralty for the supply of the mild steel to be used in the construction of vessels for the Royal Navy, the boats being two armed despatch vessels, the Iris and the Mercury. At the invitation of Sir Nathaniel Barnaby, the chief constructor of the Royal Navy, my father prepared and read before the Institution of Naval Architects a paper descriptive of the qualities of the "new material" as it was then called, and in view of the services he had rendered to the naval authorities, he was about this time elected an associate member of the Institution of Naval Architects. Afterwards came the second stage in the industrial revolution which was led by my father. Recognising the suitability of mild steel for tinplate manufacture, he succeeded in inducing some of the manufacturers to give it a trial, with the result that in the course of a year or two the Landore Company was called upon to supply some thousands of tons for this purpose, and in the result, the whole of the South Wales industry became remodelled upon a different basis. I think that I am correct in saying that it was Siemens' intention to manufacture his steel into rails only.

Yours faithfully,
JAMES L. RILEY.

Lake Magadi, Kenya Colony, E. Africa.
July 18, 1923.

[We are glad to publish this letter in view of the great work done by the late Mr. James Riley in the development of the steel industry. The paper referred to was read at the Institution of Naval Architects on April 7, 1876, on "Steel for Shipbuilding as Supplied to the Royal Navy." (See ENGINEERING, vol. xxi, p. 322). In this paper, after quoting what the late Sir Nathaniel Barnaby had said in favour of steel, the late Mr. Riley said:—"Long previous to the date when these words were spoken, it had been the desire of Dr. Siemens that the Landore Siemens-Steel Company should turn their attention to the production of steel of the finer qualities, whether of soft or hard descriptions, consequently a series of experiments extending over some months had been conducted with a view to the manufacture of plates, angles, &c., suitable for shipbuilding and boiler-making."—ED. E.].

PACIFIC COAST TIMBER CARRIED TO CHICAGO BY WATER.—On June 30 the ss. Valdez, of approximately 2,300 gross tons, passed through the Panama Canal from Gray's Harbour, Washington, bound for New York with 1,500,000 ft. of timber. On arrival at the latter port she was sent on to Chicago, and thus carried the first cargo from the Pacific Coast to Chicago via the Panama Canal. A previous vessel, the Iroquois, made a passage from Seattle to Chicago via the Panama Canal in 1920, but in that instance no cargo was carried, the ship being in ballast.

LONDON, LIVERPOOL, NORTH EAST COAST AND SCOTTISH SHIPPING.—Four books issued by the Journal of Commerce, Liverpool, deal with London, Liverpool, the North-East Coast and Scottish shipping, shipbuilding and marine engineering in each of the four areas. They give the shipping companies; the managing staffs; names and tonnage of the ships owned and their trading routes; a list of shipbrokers, of marine insurance companies, of stevedores' associations, and a directory of shipbuilders and ship repairers with the capacity of each firm. The docking facilities and other shipping information are also dealt with. The books are carefully got up and will prove very useful for reference purposes. Their price is 2*s.* each and they can be obtained from our Liverpool contemporary, whose London address is 72, Cannon Street, E.C.4.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While reports from representative manufacturers are less optimistic than was the case three months ago, there is still a considerable amount of activity displayed in the purely engineering section, with here and there the maintenance of production at something approaching full capacity. Forges and foundries have benefited from constructional work on British Admiralty account, and there is promise of increased requirements of heavy steel as progress is made with preliminary arrangements for discharging the contracts in hand. On the other hand, acid steel, in which Sheffield makers specialise, is in very limited call, buying being mostly of the hand-to-mouth variety. Makers of this class of steel are having a difficult task to meet overhead charges from the narrow margin of profit forthcoming from the restricted volume of business in circulation. British and Colonial railway requirements are still finding a good deal of work for the axle, tyre and spring plants. In this connection the big South Yorkshire engineering firms are feeling the advantage of recent schemes of amalgamation with substantial interests in the Midlands and the North. Electrical and automobile engineers are calling for a fair tonnage of alloy steels and fittings. The report circulated during the week-end that tool-makers were contemplating closing down certain departments, lacks authenticity. Business is patchy in face of political unsettlement and exchange irregularities, but orders of considerable magnitude continue to be booked for edge tools, engineers' tools, mining and quarry implements.

"Stainless Developments."—These are being followed with the closest interest. The more recent have applied primarily to the cutlery trade, but the latest discovery, which is based on electro-plating with pure chromium, opens out wide possibilities of improved rust-resisting tools, appliances and fittings in virtually every branch of the engineering and steel industries. The inventor, who for a quarter of a century has been engaged in the nickel plating trade of Sheffield, claims that articles of iron, steel, copper, brass, aluminium, and other basic materials, when thus treated, are rendered absolutely rustless and stainless. If this claim is substantiated in commercial practice as in exhaustive xperiment, the added durability conferred in the case of structural materials, tools, fittings, &c., should introduce a big element of economy.

South Yorkshire Coal Trade.—In several branches the market is distinctly firmer. A moderate demand on home account for best steam hards is supported by steady shipments from the Humber ports. Individual collieries have nearly doubled their exports as compared with certain months of last year. Cobbles, nuts and slacks are all maintained at last week's prices, the demand from home buyers having stiffened. Sellers of furnace and foundry coke occupy a strong position, there being no surplus output and barely sufficient to meet home requirements. Quotations:—Best branch handpicked, 30*s.* 6*d.* to 32*s.* 6*d.*; Barnsley best silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The drop in Cleveland pig iron prices has brought in a few buyers, but business is still on a very limited scale. There are a good few inquiries on home account, but export trade continues very quiet. No. 1 is still scarce but demand is small. Whilst substantial parcels are obtainable at 105*s.*, a little above that figure is asked for small quantities. No. 3 g.m.b. is not particularly plentiful, and though purchases have been made at 100*s.* some makers are inclined to ask rather more. Foundry 4 is on sale at 95*s.*, and No. 4 forge is steady at 92*s.* 6*d.* All the foregoing quotations are f.o.t. makers' works or f.o.b. Tees.

Hematite.—Supply of East Coast hematite though ample, is no longer abundant, due to recent curtailment of output and steady improvement in demand. Home inquiries are rather better, and a few sales to Germany and to Italy are reported. Under such conditions quotations have taken an upward turn, but they are still on a comparatively low level at 98*s.* 6*d.* to 100*s.* for Nos. 1, 2 and 3. As in normal pre-war times mixed Nos. were usually about 8*s.* above No. 3 Cleveland. The hematite quotation of 98*s.* 6*d.* is now the minimum that would be accepted either for home purposes or for shipment overseas, and indeed 99*s.* has been paid. Makers name a premium of 6*d.* for No. 1.

Foreign Ore.—Business in foreign ore continues extremely quiet, but there is a little more inquiry circulating. Nominally market quotations are based on 23*s.* c.i.f. Tees.

Blast Furnace Coke.—Durham furnace coke is still scarce, but not quite so difficult to obtain as it has been for local use. The concession quotation to consumers here runs from 40*s.* to 41*s.* delivered.

Manufactured Iron and Steel.—The volume of business passing in finished iron and steel is small, and manufacturers are quite ready to make price concessions to secure orders. In one or two branches, however, there is slightly more export inquiry. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*;

packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 13*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little improvement has taken place in the Scottish steel trade over the week and managements are not at all favourably impressed with the outlook. For one thing the demand for shipbuilding material is almost a dead letter and the long delay in securing some sort of arrangement with the boilermakers is hampering business very much. Such a large percentage of the general trade of the country is dependent upon activity in the shipyards that little all-round change for the better can be expected until conditions there show signs of improving. Even the recent shading in prices has failed to stimulate buying, as consumers of steel state that the concessions given are not nearly sufficient to induce them to enter the market meantime. The black sheet trade is moving along but slowly at present, and while most works have a fair number of orders on hand for the lighter gauges fresh bookings, particularly for the heavier sorts, are not satisfactory. For galvanised corrugated sheets there is a better demand from abroad, but low prices have had to be accepted in many cases to secure the business. The export trade over all is perhaps a shade better, but buyers are acting with much caution and are not committing themselves too heavily. Were local export quotations more akin to those in the south perhaps more business might be secured. Prices are steady this week and show no change from last report.

Malleable Iron Trade.—The position in the malleable iron trade of the West of Scotland has varied very little this week and orders are difficult to secure. There is a very poor demand for bar iron and any activity that exists at the works is in the re-rolled steel branches. Even there, however, there is much room for improvement. Prices are unchanged with "Crown" bars called 12*l.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—No change has taken place in the state of the Scottish pig-iron trade this week, and so long as prices continue easing off there is not likely to be any rush of orders. Buyers are not very plentiful just now on account of the general depression on all sides and those with business to place are not ordering any more than actual day-to-day requirements. The demand for hematite iron is still poor and the prospects are not very bright, while a similar state exists for foundry grades. Overseas trade is very slow and shows little sign of expanding yet awhile. The total demand is so poor that stocks are accumulating and the talk of further reducing production is again very general. The following are the current quotations:—Hematite, 5*l.* 7*s.* 6*d.* per ton delivered at the steel works; foundry iron, No. 1, 5*l.* 7*s.* 6*d.* per ton, and No. 3, 5*l.* 2*s.* 6*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, August 25, amounted to 410 tons. Of that total 280 tons went foreign and 130 tons went coastwise. For the corresponding week of last year the figures were 978 tons foreign and 41 tons coastwise, making a total shipment of 1,019 tons.

THE SCHOOL OF ACCOUNTANCY.—The School of Accountancy, 10, Essex-street, Strand, W.C.2, has issued a pamphlet giving particulars of its evening classes, and correspondence tuition. The prospectus will be sent upon application to the above address.

UNIVERSITY OF MANCHESTER.—The prospectus of university courses in the Municipal College of Technology, Manchester, for the session 1923–24, which opens on Thursday, October 4, and closes on Friday, July 25, 1924, has now been issued. The courses cover mechanical, electrical, sanitary engineering; applied chemistry; textile and other industries; mining, mathematics, physics, &c., of which full particulars are given.

BRIDGING THE LITTLE BELT.—In the Finance Committee of the Danish Folketing M. N. M. Slebsager, Minister of Public Works, recently submitted a scheme for the construction of a bridge across the Little Belt, between Jutland and the island of Funen. The proposal, says the *Danish Foreign Office Journal*, has been worked out by the engineering staff of the State Railways, and provides for a double-track, high-level bridge, 33 m. above water level, thus allowing even the largest ships to pass under it. The bridge would have three navigable spans, one of 105 m., and the other two 90 m. each. The total cost is estimated at nearly 30 million kronen. If the bridge is not constructed in the comparatively near future certain extensions and improvements of the ferry service are regarded as essential, and these would cost about 12 million kronen, so that the real additional expenditure involved by the erection of a bridge would be between 18 million and 19 million kronen, while the annual expenditure would be reduced by over two million kronen. For the purpose of preliminary investigations of the sea bottom and the tide water, the Minister has asked for a special grant of 50,000 kronen. The introduction of the necessary Bill in the Rigsdag is expected to be made in the early autumn.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to the returns of the Board of Trade 13,013,760 tons of coal were raised in South Wales in the three months ending March 31 last, of which 777,650 tons were consumed at the mines and 294,386 tons by the miners, leaving 11,941,724 tons for disposal. The total proceeds amounted to 12,222,751*l.*, averaging 20*s.* 5·65*d.* per ton, while the net costs were 10,883,117*l.* or 18*s.* 2·73*d.* per ton, leaving a profit of 1,339,634*l.* or 2*s.* 2·92*d.* per ton. Wages costs amounted to 7,345,532*l.*, or 12*s.* 3·63*d.* per ton, stores and timber 1,606,256*l.* or 2*s.* 8·28*d.* per ton; management, salaries, insurances, depreciation, &c., 1,570,368*l.*, or 2*s.* 7·56*d.* per ton, miners' welfare contributions to 54,224*l.*, or 1·09*d.* per ton, and royalties 417,738*l.* or 8·40*d.* per ton. There were 219,779 workers employed, and the total man-shifts above and below ground were 15,395,137; the man-shifts lost, which could have been worked, were 1,283,935, and the output per man-shift was 16·91 cwts. and the earnings per man-shift averaged 9*s.* 6·51*d.* Conditions on the coal market have not shown any material alteration during the past week. Though actual business remains restricted the tendency is somewhat better as sellers are adopting a hold-off policy in view of the threatened strike of anthracite miners in America and the more hopeful prospects of some arrangement being entered into over the Ruhr problem. Dry large coals are much stronger and more difficult to secure. For the best sorts up to 31*s.* is asked with 30*s.* the minimum, though ordinary grades can be secured from 28*s.* 6*d.* Sellers are, however, refusing to sell unless buyers give a guarantee that the coal is not to be shipped to America. Best Admiralty large is quoted up to 31*s.* but supplies are available at 29*s.* to 30*s.* with seconds round 28*s.* and Monmouthshire from 27*s.* to 29*s.* Small coals of nearly all descriptions are in ample supply at prices ranging from 14*s.* to 21*s.*, according to quality. Exports of coal as cargo from South Wales last week amounted to 568,800 tons compared with 459,700 tons in the preceding week. Of the total 228,600 tons went to France, 91,600 tons to Italy, 75,500 tons to South America, 50,300 tons to Spain, 11,300 tons to Portugal, 9,000 tons to Greece, 30,700 tons to British coaling depots, 700 tons to Canada, 16,800 tons to Belgium, 19,900 tons to Holland, 13,900 tons to Germany, and 20,100 tons to other countries. Patent fuel keeps quiet with prices from 30*s.* to 33*s.* 6*d.* and coke is also less active and offered at 45*s.* to 55*s.* for export.

Iron and Steel.—Exports of iron and steel goods last week totalled only 11,121 tons. Tinplates and ternetplates amounted to 5,716 tons compared with 13,082 tons in the previous week, blackplates and sheets to 2,956 tons against 5,832 tons, galvanised sheets to 732 tons against 2,350 tons and other iron and steel goods to 1,717 tons against 923 tons.

COMMERCIAL SECRETARY FOR TURKEY.—The Department of Overseas Trade announces that Colonel Harold Woods, O.B.E., has taken up the duties of Commercial Secretary (Grade II) for Turkey in succession to Captain C. H. Courthope Monroe, resigned.

INSTITUTION OF NAVAL ARCHITECTS.—The Martell Scholarship in Naval Architecture (1923) (130*l.* per annum for three years) has been awarded by the Council of the Institution to Mr. F. H. Sears of H.M. Dockyard, Chatham, and the Earl of Durham Prize to Mr. R. J. Halsey of H.M. Dockyard, Portsmouth.

GERMAN IMPORTS INTO NEW SOUTH WALES.—According to a Customs statement, forwarded by H.M. Trade Commissioner at Sydney, the value of imports of German origin into New South Wales during the month of May was 23,246*l.*, as compared with 22,562*l.* in April and 22,125*l.* in March. The principal articles imported, according to their value, included musical instruments, patent leather, knitting machines, cutlery, upright pianos, clocks and opera, field and marine glasses.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—A Goldsmid Entrance Scholarship of the value of 120*l.*, tenable in the Faculty of Engineering of University College, London, will be awarded in September. Entry forms must be received by the Secretary of the College not later than September 8. In connection with the examination for the scholarship, five bursaries may be awarded to engineering students who require financial help to enable them to take a university course in engineering.

THE SIR JOHN CASS TECHNICAL INSTITUTE.—The syllabus of classes issued by this institute states that the 1923-24 session commences on Thursday, September 20. Students will be enrolled on Monday, Tuesday and Wednesday, September 17 to 19, from 6 to 8.30 p.m. The courses of instruction, which are held from 6 to 10 p.m., meet the requirements of those engaged in chemical, metallurgical, electrical, petroleum and the fermentation industries. Well-equipped laboratories provide for special investigations and research. Courses prepare students for the examinations of London University, the City and Guilds of London Institute, and the Institutes of Physics, Chemistry and Brewing. A distinctive feature are courses in Brewing, Micro-Biology, Petroleum Technology, Mathematical Statistics, Metallography and Pyrometry, Heat Treatment, Mechanical Testing of Metals and Alloys, Foundry Practice, Mining and Surveying, etc. The address of the institute is Jewry-street, Aldgate, E.C.3.

NOTICES OF MEETINGS.

THE INSTITUTION OF NAVAL ARCHITECTS.—Summer Meeting, Holland, September 1 to September 8. Monday, September 3, at 10 a.m., at the Bad Hotel, Flushing. Papers to be read and discussed—"Notes on the Curves and Formulæ for regulating the Watertight Subdivision of Passenger Ships," by Sir Archibald Denny, Bart., LL.D.; "Sub-division of Large Passenger Steamers," by Mr. A. C. F. Henderson; "Dutch River Lighters," by Mr. A. M. Schippers. Tuesday, September 4, at 8.35 a.m., visits to various works in Amsterdam. Wednesday, September 5, at 10 a.m., at the Kurhaus Hotel, Scheveningen: "Steam Turbines for Marine Propulsion in Holland," by Professor D. Dresden; "A Few Results from Practical Experience with Mechanical Stokers applied to Marine Water Tube Boilers," by Mr. W. J. Muller; "Internal Combustion Engines Exhausting into Low-Pressure Turbines," by Lieut.-Col. F. Modugno, R.I.N.; "The Theory of Bending," by Professor G. W. Hovgaard. Thursday and Friday, September 6 and 7, at 9.10 a.m., visits to works in Rotterdam and excursions. September 7, at 7.45 p.m., Institution Dinner at the Kurhaus Hotel, Scheveningen.

INSTITUTE OF MARINE ENGINEERS INCORPORATED.—Thursday, September 6, 1 p.m. Luncheon at the Shipping and Engineering Exhibition, Olympia, London, W., where the President and Council are looking forward to meeting all members home from abroad, by invitation of the organisers, Messrs. F. W. Bridges and Son; 3.45 p.m., "A Note upon Cast Iron for Marine Engine Castings from the Metallurgical and Engineering Points of View," by Messrs. H. J. Young, F.I.C., and E. Wood, B.Sc. Thursday, September 6, 7 p.m. Exhibition, Olympia. Paper on "Life-Saving Appliances on Large Passenger Steamers," by Mr. E. W. Blocksidge.

QUALIFICATION OF SURVEYORS AND MINE MANAGERS.—An examination for first and second class certificates as managers and under-managers of mines will be held on November 21 and 22, at Edinburgh, Newcastle-upon-Tyne, Sheffield, Wigan, Cardiff and Birmingham. The written part of an examination for certificates of qualification as surveyors of mines will be held at the same centres on November 22. Applications for the necessary forms should be made not later than October 1. In order that the appropriate forms may be sent, it is important that candidates should state whether they have already sat at one or more of the Board's examinations. Letters should be addressed to The Secretary, Board for Mining Examinations, Mines Department, Dean Stanley Street, Millbank, London, S.W. 1.

TECHNICAL COLLEGE, BRADFORD.—The following special courses will be delivered during the winter session under the direction of Dr. R. E. Stradling, head of the department of Civil Engineering and Building:—For the building trades: (1) Materials and structures; (2) practice workshop courses for journeymen: (*a*) carpentry and joinery, (*b*) masonry and brickwork, (*c*) plasterers' work, (*d*) reinforced concrete; (3) special plumbers' course in lead burning and acetylene welding. In addition, a special course for teachers of building subjects on building science (materials) with practical work in the building laboratory. The courses are intended for persons over 25 years of age. They will especially meet the needs of foremen, clerks of works and architectural and engineering assistants. Further particulars may be obtained on application to the Principal, Technical College, Bradford.

THE LATE DR. ING. OSKAR LASCHE.—Dr. Lasche, who died suddenly some weeks ago in Berlin, was well known as director of the turbine department of the Allgemeine Elektrizitäts-Gesellschaft, as well as for his experimental work on lubrication, gearing and electric machinery, and for his contributions to technical journals; years ago he contributed a few articles to our columns. Born at Leipzig in 1868, he went to school there, worked in several engineering shops, attended the Technical High School at Charlottenburg and became Riedler's assistant. Having for short periods continued his practical training in Chicago, London and Winterthur, he returned to Charlottenburg as chief of the construction section under Professor Riedler. In 1896 he joined the A.E.G., which had amalgamated with the Union Company, and soon became director of the steam turbine department of the A.E.G., a post which he held until his death. His largest steam turbine was the 50,000 kw. turbo-dynamo for the Goldenberg electricity works; his department also built many turbines and Diesel engines for the German mercantile fleet and navy. He designed the locomotive for the Berlin-Zossen electric railway of 1901, for which achievement our Institution of Electrical Engineers accorded him a prize. Later he reorganised the scientific and technical work of the various establishments of his company and took a great interest in the educational training of engineers, originating the technico-scientific lectures of the German industry and devoting himself in particular to the development of technical continuation schools. Having during the war been chiefly occupied in the study of the properties of engineering materials, he was, after the death of E. Heyn, elected president of the Deutsche Gesellschaft für Metallkunde, in the foundation of which, by the Verein Deutscher Ingenieure in 1920, he had had an active share. He was a very conscientious man of remarkable capacity for work and of great persistence.

EXHIBITS AT THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION AT OLYMPIA.

CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

(*For Description, see Page* 265.)

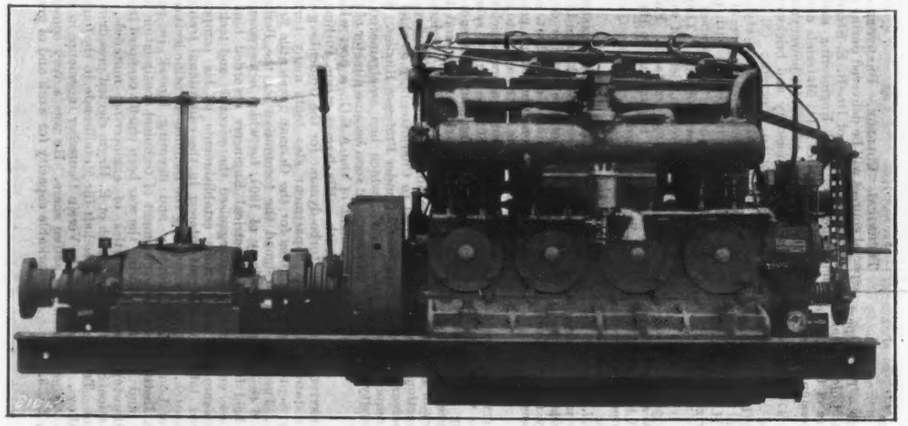


Fig. 31. 60-B.H.P. Marine Engine.

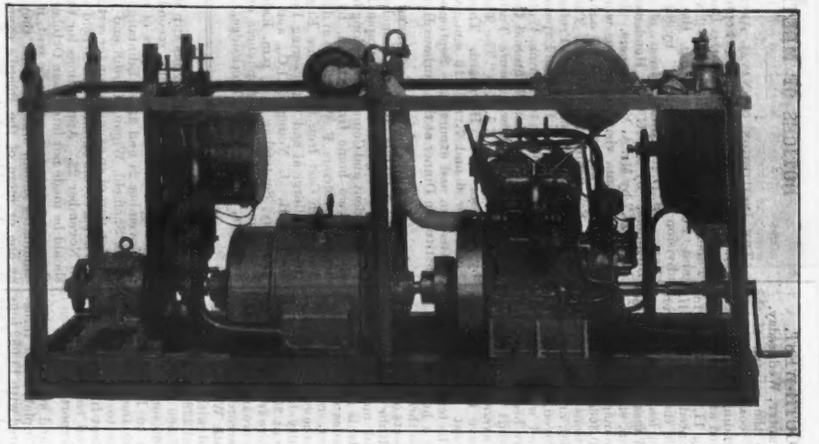


Fig. 32. Portable Electric Welding Set.

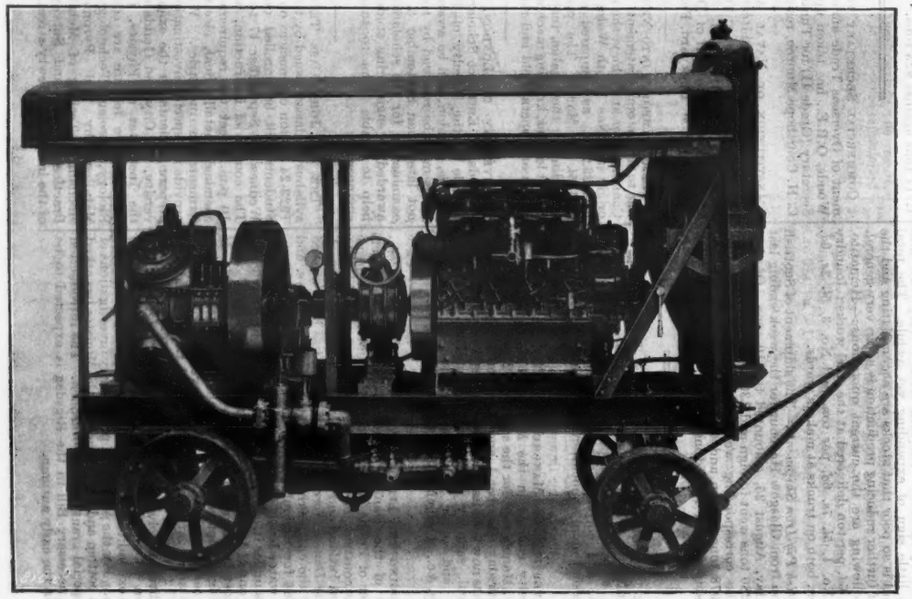


Fig. 33. Portable Air-Compressor for Contractors' Use.

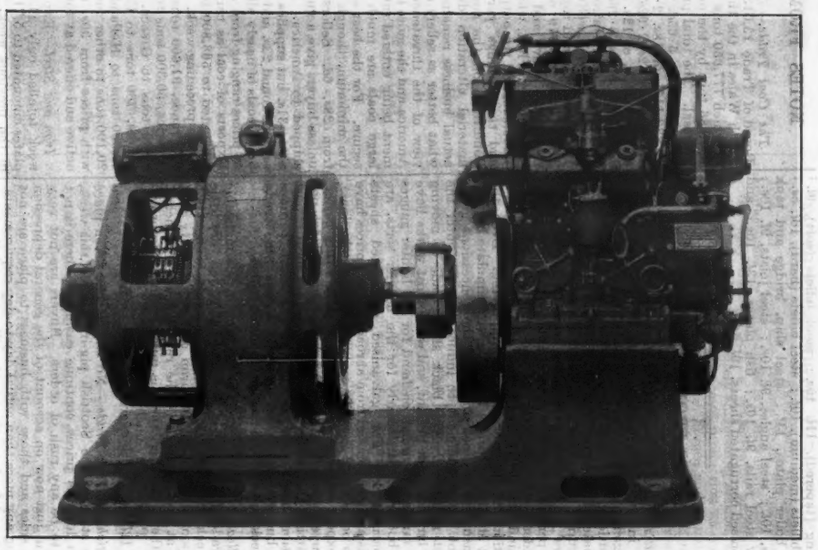


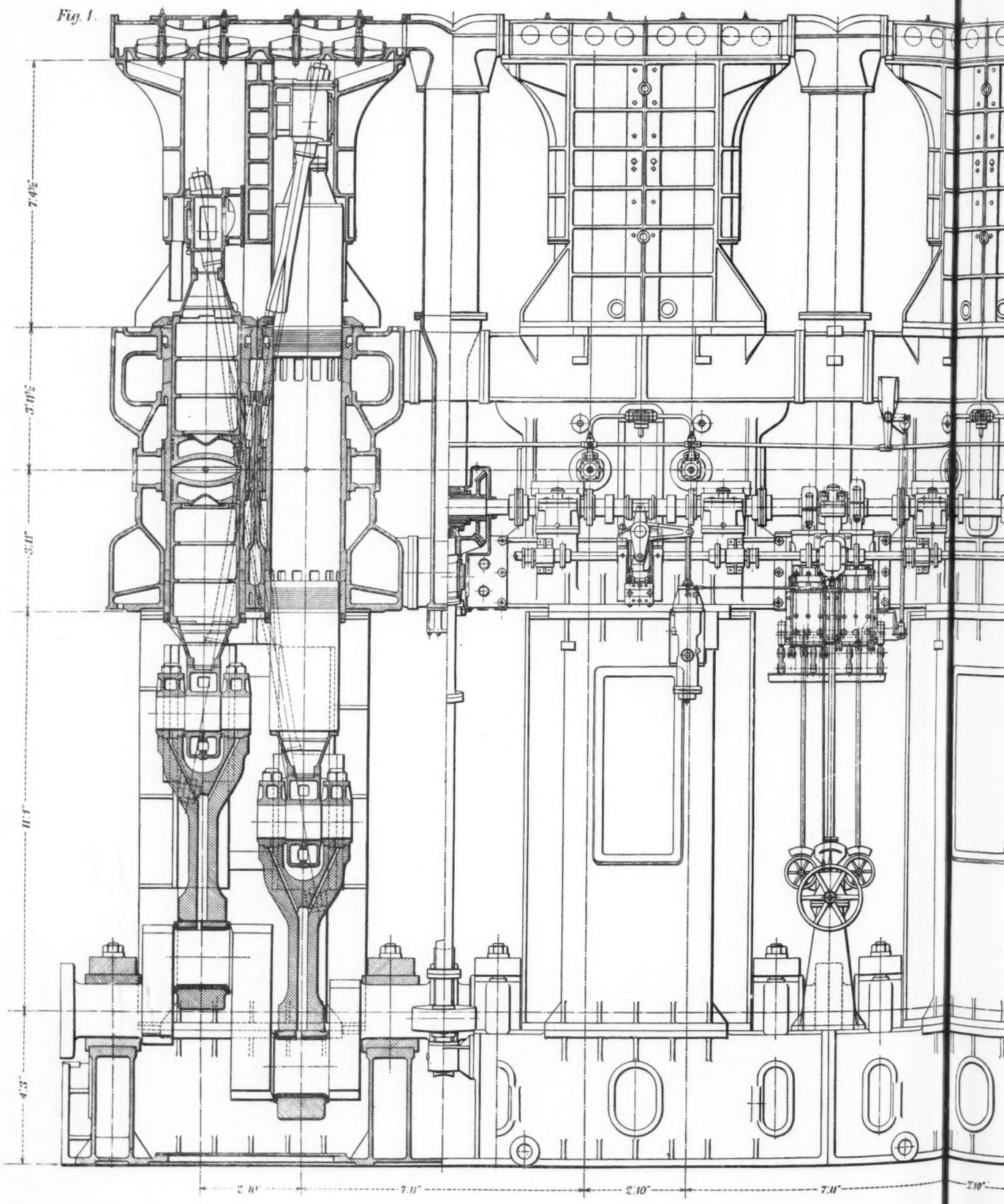
Fig. 34. 7·5-Kw. Electric Lighting Set Driven by Paraffin Engine.

3,000-B.H.P. PALMER CAMELLAIRD-FULLA

CONSTRUCTED BY MESSRS. PALMERS' SHIPBUILDING AND

(For Description see Page

Fig. 1.



IRD-ULLAGAR MARINE OIL ENGINE.

HIPBUILDING AND IRON COMPANY, LIMITED, ENGINEERS, JARROW.

r Description see Page 265.)

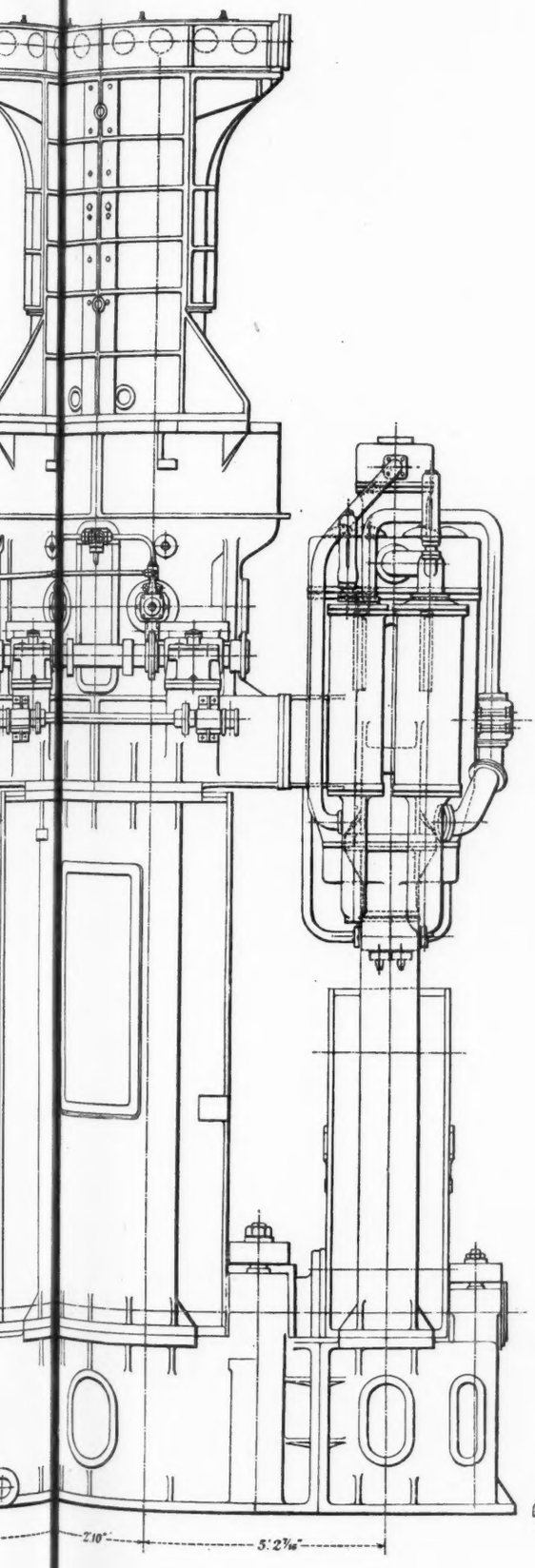
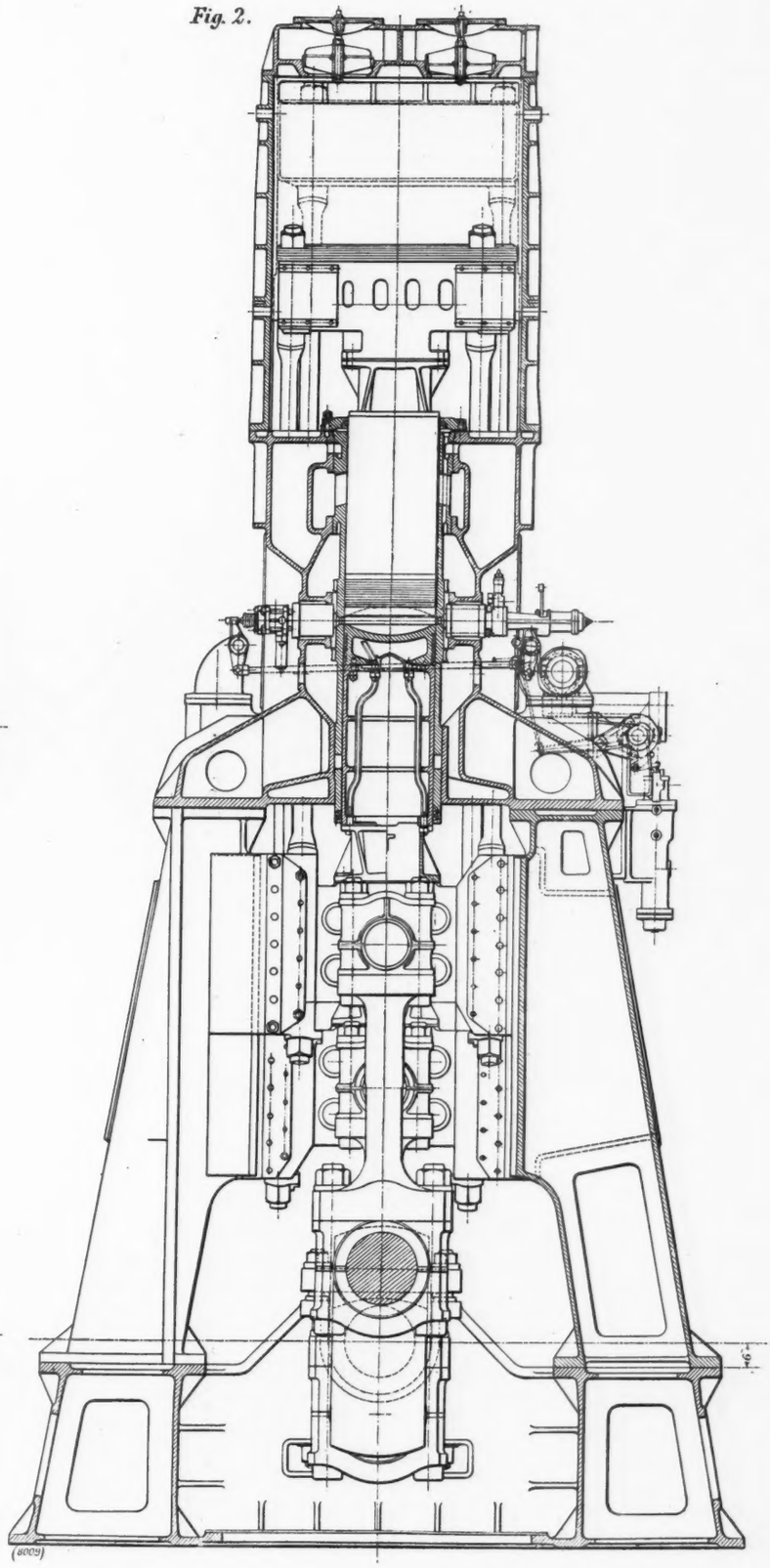


Fig. 2.



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ADVERTISEMENT RATES.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

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ITALY : U. Hoepli, Milan. Anonima Libraria Italiana, Torino. And any post office.

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UNITED STATES : For Subscriptions, New York : W. H. Wiley, 432, Fourth Avenue. For Advertisements : J. S. Allan, 30, Church-street, New York.

CONTENTS.

	PAGE
A High Speed Stroboscope (*Illus.*)	255
Experiments on the Natural Vibration of Aeroplane Spars (*Illus.*)	256
The Industrial Applications of the Electric Furnace (*Illus.*)	257
The Shipping, Engineering and Machinery Exhibition at Olympia (*Illus.*)	259
The Palmer-Camellaird-Fullagar Marine Oil Engine (*Illus.*)	265
3-Ft. 9-In. Portable Universal Drilling Machine (*Illus.*)	266
Trials of a Turbo-Generator at the Dalmarnock Power Station	266
Electrical Propulsion of Ships (*Illus.*)	267
Letters to the Editor.—Dangerous Voltages. "The Centenary of Sir William Siemens"	268
Notes from South Yorkshire	268
Notes from Cleveland and the Northern Counties	268
Notes from the North	269
Notes from the South-West	269
Notices of Meetings	269
Indexes and Compendiums	271
The Liverpool Meeting of the British Association	272
Tests of the 15,000 Kw. "Multiple Exhaust" Turbine at Dalmarnock (*Illus.*)	273
Rotating Discs of Conical Profile (*Illus.*)	274
Literature	275
Books Received	277
Industrial Notes	277
Integrating Coal Meters (*Illus.*)	278
Notes on New Books	278
Hydro-Electric Station at Cynwyd, North Wales (*Illus.*)	279
The Liverpool Meeting of the British Association	280
Suggested Methods of Tension Testing of Metallic Materials (*Illus.*)	280
The Power Factor and Slip of an Induction Generator (*Illus.*)	282
Electric Heating of Finishing Rolls of Sheet and Tin Mills (*Illus.*)	283
Apprentices for the Royal Air Force	284
ENGINEERING Patent Record (*Illus.*)	285

Two-Page Plate.—3000-*B.H.P. PALMER-CAMELLAIRD-FULLAGAR MARINE OIL ENGINE.*

ENGINEERING.

FRIDAY, AUGUST 31, 1923.

INDEXES AND COMPENDIUMS.

THE importance of an index depends on the subject-matter of the book, and what may be called the syntax of its information. Where each item stands by itself, as for instance in a table of logarithms, or is presented as without relation to any other parts of the book except those that come immediately before and after it, an index may be useless. If any guide is wanted to the contents of such a work, a table of contents following the order of treatment adopted in the text is usually sufficient. Technical and scientific books are not usually of these classes. In them much of the information given in one context has to be applied in others, and in different parts of the book reference has to be made to the same results in different aspects. The nature of the subjects under discussion makes this inevitable, and the necessity is often increased by the circumstance that the information is derived from different works or workers. Where, therefore, the book is of any substantial length, a reader who refers to it for information on a particular subject needs an index to tell him something more than the pages on which the subject in which he is interested is discussed. Seeing that the same subject may be discussed in many aspects, while he for the moment may be concerned only with one, the entry against each page must state the aspect in question clearly enough to identify and differentiate it.

Indexes of this sort are perhaps not as common in any class of literature as they once were, though they are found from time to time, particularly in historical and biographical works. In technical and scientific books, whether collating old work or describing new, they are conspicuously absent. This is to be regretted for more reasons than that without such indexes far more time may be required for making references. The omission of an analytical index deprives the author or authors of a book or a report (not to mention its readers) of a desirable safeguard against casual discrepancies in expression and even in statements of fact. Such discrepancies may occur, for instance, when reference has to be made to the same result in more than one connection, for nothing is easier than that the writer should express the result somewhat differently when he describes it the second time, and leave the attentive reader uncertain whether the discrepancy means anything or nothing. Similarly, in the absence of the collation that would be involved in preparing an analytical index, figures—limits, for example, or results taken from tables—may be given variously in different passages of the text, and references be even made to results that in fact are not to be found in the book, especially if it is a report, though originally they were meant to be included. As a consequence a conscientious reader may waste much time in trying to bring these loose ends together. In some instances they may turn out to have no significance, and the time so lost be the measure of the damage. Sometimes, however, they may be the result of a real discrepancy, arising it may be from fresh information acquired while the work was being written, or from a slip made by one of two contributors ; and the work goes forth spotted with such instances of loose exposition, to the confusion of the reader and the discredit of all concerned in the production.

The construction of an analytical index should, in fact, be a check on the conformity of the several parts of a work with each other. It has been said that the author of the book should himself prepare the index, whoever might have written the text. This may not be necessary or desirable ; but the spirit of the remark is right in so far as it suggests that the maker of the index has a responsibility comparable with that of the author. For the convenience of the reader the index has to reproduce the constituents of the work in a recognisable microcosm ; but at the same time it has to serve as a sort of audit or stocktaking of its contents, by which the author or authors may be saved from looseness of statement and discrepancies. In much recent work such looseness of exposition has been conspicuous, even when the constituent results have been admirable. If experimental work, for example, is to yield its full value, the same order of care and acumen must be given to summing up what the results actually do and do not mean as to planning and carrying out the investigation. What is said in one part of a report on it ought not to be thrown into doubt or contradicted in another. Yet with a long report or an account of a considerable volume of work nothing is easier than that such discrepancies should arise, if the final record is not duly audited ; and nothing can assist the audit more effectively, or furnish a more useful preparation for drawing accurate and comprehensive conclusions, than a careful and intelligent analytical index.

Such an index is of no less value to the reader. Perhaps its absence is most felt in technical compendiums, which purport to embrace in practically complete treatises either the entire field of engineering practice or some individual branch of it. The purpose of such works is to collect under one cover what a busy man might otherwise have to seek in many places, and to discharge the duty of a silent technical secretary in everything except the operation of turning up the references. If a man gets into the habit of using such assistance, he tends naturally to depend upon it, and on his faith in it may speculate large quantities of time before the year is out. To most eyes the time is not spent pleasantly, because the text is mostly printed in "pearl," which is not agreeable reading. It has to be so printed, because the compendium would not otherwise be compendious. And even as it is, engineers for some years past have been wondering whether these compilations are as compendious as they might be ; whether they save their readers the time that their contents suggest they might save.

Such speculations do not indeed necessarily involve the purist view that such works are instruments of scientific demoralisation. Some men unquestionably hold that a man who has to turn up more than is given in indispensable tables should rely on ampler sources of information, and lead his practice to depend more on his own first-hand

experience and information than is likely to happen when it is picked out of a scrap-book. This view is open to two criticisms. On the one hand men are busy, and do not necessarily demoralise their practice when they seek to economise their time. On the other hand the compendiums, though they are bound in some measure to preserve the character of scrap-books, show an increasing disposition in their producers to edit their works helpfully, and even from time to time to couple their extracts with sound general accounts of the several branches of work to which they relate. No one is invited or intended to learn his profession from a single volume in microscopic type, whose pages, counting tables and figures, contain space enough to print the Bible two or three times over. What such collections are obviously meant for is to recall or supplement the user's previous knowledge; and their existence is abundantly justified if they do recall it accurately and conveniently.

The same circumstances, however, as create a need for such books, which increases as the field of practice widens, make them increasingly more difficult to make convenient; or at least the arrangements that were convenient with a relatively small bulk of matter grow less and less adequate as the bulk increases. The difficulty is that no branch of practice is created ready made. It grows bit by bit; some bits are important to many branches of practice; but even in the same branch of practice different pieces of work may deal with different aspects of the subject, or set out with different data or postulates. If a collection of such information is to be used as doctors require domestic medicines to act—*cito, tuto, jucunde*—its immediate, safe, and agreeable use depends primarily on how quickly the reader can ascertain how much of the required information is contained in the volume, and where it is to be found. Sometimes, indeed, he may not even know how much of the information is available anywhere, and must depend on the book itself not merely to give him the answers to his questions, but to tell him to what questions he can get answers, and which are likely to be the most worth asking.

Nor, indeed, does this difficulty apply merely to recent knowledge. There are any number of manufactured objects that are applied in several or many branches of engineering, and crop up in a variety of contexts in different parts of the book. Take such a subject as pipes. Even in an ascetic compendium, which contains no mention of tobacco pipes, there may be easily over a hundred separate references in the index to the various kinds and properties of pipes, and even these are as likely as not to omit something important for the reader's purpose, which nevertheless may be modestly concealed in some other part of the book. One page may give the thickness of hydraulic pipes, and another the thickness of iron, water and hydraulic pipes; two references may point to the speed of water through pipes, half a dozen to its flow, and perhaps seven to its velocity, and what these references may be and whether they are the same or different can be discovered only by turning up the several pages quoted, perhaps some hundreds or thousands of pages apart. No hint may perhaps be given under the heading of specifications to indicate that the book contains, as it may, several important standard specifications for pipes; if in fact you want to know what information is ready and waiting for you, you have to hunt through a mass of entries, sometimes superfluous, sometimes insufficient, and as often as not you may spend many times as much energy in the search as is required for extracting the information when once it has been located.

What seems to have happened is that compilers of compendiums have forgotten that a sufficient index is as necessary to a book of reference as a handle is to a tool, and the more complex and voluminous the information in the book, the clearer and more detailed must the index be if the book is to pull its weight. This requirement is not to be satisfied merely by multiplying synonyms in the index headings on the chance that the reader may hit one if he misses the others. That is the easiest and most perfunctory way of amplifying an index, and the least efficient. What is not so easy is that the index reference shall describe succinctly the *differentia* of the matter indexed, and group together those subject matters that are allied to each other. A page full of separate lines under one heading takes far more examination and yields less chance of results than when the lines are grouped together under subjects alphabetically and intelligently. If an index, for instance, contains the heading "Specifications," there is no advantage in beginning every subsequent line under that heading with a dash three-fourths as long as the description of the specification; a reasonable indent and allied headings printed after each other in alphabetical order in solid groups would be far more helpful, and only a small part of the space saved need be devoted to cross-references.

For some reason scientific and technical books have long had to put up with indexes that do far less than justice to their contents. This may be no great hardship where the book is slender, or is of little worth; but the better the book, and still more the more complex and voluminous its information, the better its index must be if it is to enable the book to be used to proper advantage. To compendiums of practice good indexes have always been desirable, and it is not too much to say that the absence of such indexes to books of their present prodigious girth reduces their value to their readers to an extent that may offset the merit of the increased information that is buried within them. No one is likely to covet the labour and risk of producing yet another compendium unless some very strong inducement is offered, especially when regard is had to the excellent quality of much that is contained in the present works. But if users of such books had the choice of one that gave less information, but gave it in a form conveniently and readily accessible, they would be likely to prefer it to the imperfectly dissected haggis into which compendiums seem to have grown.

The reconstruction of the indexes to existing compendiums would doubtless be a heavy job, and take a considerable time, but it would add vastly to their usefulness and therefore to the extent to which they would be used. The labour of providing analytical indexes for fresh work, such as reports of technical experiments and investigations, though it would often not be slight, would be incomparably less; and its difficulty would be reduced as writers became more alive to the fact that for the purposes of the index the statements in different parts of their work must be consistent with each other, and that different terms and phrases must be used only when there is a real difference of meaning. Reports so edited as to afford material suitable for such an index would usually have to delete some useless repetitions, and thus shorten their own bulk. They would be free from variations in the expression of the same statement, which may be very troublesome to a reader till he has satisfied himself whether the statement is or is not the same. Sometimes even they might help the writer or writers to realise a little more clearly what their results really do mean; and often they would perform this inestimable service for their readers.

THE LIVERPOOL MEETING OF THE BRITISH ASSOCIATION.

The 91st meeting of the British Association, which is to be held at Liverpool from Wednesday, September 12, to Wednesday, September 19, promises well. Fortunately—for Liverpool, which will then entertain the Association for the fifth time, as only Birmingham and Edinburgh have done so far—has a high reputation to maintain in that respect. When the Association met there for the first time in 1837, William Cavendish, Earl of Burlington (afterwards sixth Duke of Devonshire) was President; he had worthily represented Cambridge University in the House of Commons, and later became President of the Iron and Steel Institute in recognition of his work for the development of the iron and steel industry, especially at Barrow-in-Furness. Of the sections in which we are specially interested, namely, A, B and G (those dealing with Mathematics and Physics, Chemistry and Engineering), the sectional presidents were David Brewster, Michael Faraday, and the Rev. Dr. Robinson. In 1854 the Earl of Harrowby presided; and his colleagues in charge of the sections just named were G. G. Stokes, W. A. Miller (assayer to the Mint and astronomer), and John Scott Russell, the naval architect. At the third Liverpool meeting of 1870, Thomas H. Huxley was President, and Clerk Maxwell, Henry E. Roscoe and Charles Vignoles presided in the three sections referred to, while Tyndall and Rankine delivered the evening discourses, and John Lubbock the lecture to working classes. At the fourth meeting of 1896 the attendance rose to 3,181, a figure only twice exceeded, at Newcastle in 1863 (3,335 members of all classes), and at Manchester in 1887 (3,838 members). The President was Sir Joseph Lister; the three sectional presidents were J. J. Thomson, Ludwig Mond and Sir Douglas Fox.

Thus the president-elect of this year's meeting, Sir Ernest Rutherford, and his colleagues in Sections A, B and G, namely, Professor J. C. McLennan, of Toronto, Professor F. G. Donnan, of University College, London (formerly of Liverpool), and Sir Henry Fowler, will look back upon a series of distinguished precedessors in their respective offices. The researches of the president and the subject of his address on "The Electrical Structure of Matter" (to be delivered on the first Wednesday evening) will recall the 1896 meeting, especially in Section A, which then met in Professor Oliver Lodge's lecture hall. The work of Maxwell and of Hertz had already borne fruit. The new radiations, Becquerel, Lenard, Röntgen, cathode and positive rays, remained mysteries, and the study of their nature, eagerly discussed at the meeting, was sufficient for the time. Lenard had come over from Aachen, Elster and Geitel from Braunschweig, together with many other foreign scientists not particularly interested in radiations. Mr. E. Rutherford was joint author, with Professor J. J. Thomson, of a paper on "Electric Conduction through Gases Exposed to Röntgen Rays"; but it was scarcely understood how shaky the "indestructible and indivisible atom" had become, though chemists scoffed at the new radiations. How those radiations have revealed to us the planetary character of the atom and an electrical structure of matter, Sir Ernest Rutherford will at the ensuing meeting be pre-eminently competent to expose, while the distinguished visitors from abroad, Bohr and Coster from Denmark; G. N. Lewis, Millikan and R. W. Wood from America; Ehrenfest from the Netherlands; Langevin from France—Germany remaining unrepresented—will help to impart to the discussion that interest which Kelvin, Rayleigh, Fitzgerald, S. P. Thompson, Bjerknes and others gave to the meetings of an earlier date.

At Liverpool, most of the sections will this year be less overburdened with papers than they were at the meeting in 1896, when the sectional proceedings extended into the afternoon and the Saturday, now universally given to excursions, was also a business day. Yet some of the sections have very long lists of instructive papers, of which they can only dispose by holding afternoon meetings. Among these is Section K, Botany, which justifies in this way its right of independent existence—a right questioned last year when a reduction of the number of thirteen sections was suggested.

Moreover, greater stress is now quite rightly being laid on general joint discussions than upon dealing with isolated papers. The discussions on human fatigue, production, wages, standard values, and cognate subjects will bring members of the sections with which we are chiefly concerned into more direct contact with Sections E and F, Geography and Economics, and with I and J, Physiology and Psychology, and L, Education.

We publish the programmes of Sections A and B on another page of the present issue, having already given the full programme of Section G on page 114 of our issue of July 27. The general programme further comprises one evening discourse, to be delivered on the Friday evening, by Professor G. Elliot Smith, on "The Study of Man," a reception by the Lord Mayor (Mr. Frank C. Wilson) on the Thursday, and a scientific soirée at the University on the Tuesday. An exhibition of scientific apparatus will also be held in the Central Technical School in Byrom-street during the whole week of the meeting, and the list of works thrown open to the visits of members is large.

The officers of the British Association are: President, Sir C. S. Sherrington (President, Royal Society), who will vacate the chair at the Philharmonic Hall

on Wednesday, September 12, in favour of the President-elect, Sir Ernest Rutherford, F.R.S., of the Cavendish Laboratory, Cambridge; Treasurer, Dr. E. H. Griffiths, F.R.S.; General Secretaries, Professor J. L. Myres, D.Sc., of Oxford, and Mr. F. E. Smith, F.R.S., Director of Scientific Research at the Admiralty; Secretary, Mr. O. J. R. Howarth, M.A. The offices of the Association, at Burlington House, will be closed on September 5. The local secretaries at Liverpool are:—Dr. A. Holt, for some years recorder of Section B; Mr. Walter Moon, Town Clerk of Liverpool; and Mr. Edwin Thompson.

TESTS OF THE 15,000-KW. "MULTIPLE EXHAUST" TURBINE AT DALMARNOCK.

SOME two years ago Mr. K. Baumann, of the Metropolitan-Vickers Company, read a notable paper* on steam turbines before the Institution of Electrical Engineers. In this he described a highly ingenious method of increasing the effective area available for passing the exhaust steam to the condenser. With the high vacua now desiderated designers have met with considerable difficulty in providing adequate steamways for the enormous volumes of steam discharged at these low pressures, and in certain cases the passages have been so restricted and the consequent velocity of flow so high that over 8 per cent. of the energy theoretically available for work has been uselessly expended merely in delivering the steam to the condenser. Mr. Baumann's "multiple exhaust" method of meeting the difficulty was described in the paper above referred to, but certain of those who took part in the discussion made dismal predictions as to the efficiency of the device. They prognosticated excessive losses in the additional blading, and, in short, condemned the scheme not merely as useless but as actually pernicious.

A special interest attaches accordingly to the results achieved with the 15,000-kw.–18,750-kw. turbine at the Glasgow Corporation Power Station, Dalmarnock, where Mr. R. B. Mitchell had the enterprise to install this large unit in which Mr. Baumann's multiple exhaust was embodied.

Engineers on several past occasions have had to thank Mr. Mitchell for the liberal-minded way in which he has given particulars of the operation of his plant, and we are further indebted to him for permission to publish the test results of this large unit, which we reproduce on page 266. These figures are the more welcome in that reliable test figures for impulse turbines have been but rarely available. It should be added that the intermediate feed-heater was not in action during the tests, and the consumptions recorded are therefore strictly comparable with those of turbines not embodying this feature.

From the data given above it will be seen that the overall efficiency ratio of the turbine at its most economical load is 73·3 per cent. "steam to electric," taking as basis for the calculation the condition of the steam at the stop valve. Of course, efficiency ratios *per se* are of very little theoretical or practical importance, a fact which Continental engineers seem extraordinarily slow to grasp. The efficiency ratios of two turbines are in fact comparable only when the running conditions are identical, and from the above figure it would be impossible to draw any conclusion as to efficiency or the reverse of the multiple exhaust. Mr. Mitchell has, however, been good enough to give us some additional figures which make it practicable to apply to the turbine Martin's method of analysis which was described in ENGINEERING of January 6, 13, 20, 27 and February 3, 1922, and this analysis shows quite conclusively that the efficiency of the multiple exhaust section of the turbine cannot be materially different from that of the simple impulse stages immediately preceding it.

Mr. C. T. R. Wilson showed many years ago that when wet steam is expanded, the expansion does not take place in conditions of thermal equilibrium, but that the condition of supersaturation is maintained throughout. As one consequence, it follows, were a turbine of unit efficiency operated with non-superheated steam, the true heat drop would prove to be substantially less than that calculated from the usual tables and charts. Unfortunately, no experimental investigation has been made as to what relation holds between the pressure and volume of supersaturated steam during an adiabatic expansion, and *a fortiori*, there is a similar lack of direct knowledge as to what this relationship may be when such steam is expanded with less than unit efficiency. The only course open has been to deduce the actual thermo-dynamic head available in such expansions from a comparison of the steam rates of turbines working with different degrees of superheat and with different vacua.

From the results of such a comparison Martin arrived at the empirical rule that the true thermo-dynamic head for expansions below the saturation line might be expressed with sufficient accuracy for practical purposes by the formula

$$U = \psi u_s,$$

where U denotes the true thermo-dynamic head and u_s the adiabatic heat drop assuming that the expansion had taken place in conditions of thermal equilibrium. The coefficient ψ is given by the empirical expression

$$\psi = 1{\cdot}0352 + 0{\cdot}04\,\frac{x}{100} - \eta\left(0{\cdot}089 + 0{\cdot}047\,\frac{x}{100}\right)$$

where x denotes the ratio of the initial to the final pressure and η the hydraulic efficiency, or as it is sometimes called, the stage efficiency of the turbine. An alignment chart for ψ was published on page 129 of our issue of February 3, 1922.

Means are thus provided for determining the true stage efficiency of turbines working with wet steam which, there is every reason to believe, is practically the same as if the steam were superheated.

Mr. Mitchell has been good enough to give us the following additional data showing the pressures in the nozzle boxes and in the first compartment of the turbine at the different trials.

Load in kilowatts	18,200	15,650	11,800
Stop valve pressure, lb. per square inch (gauge) ...	253	256	257
Pressure in nozzle box No. 1, lb. per sq. inch (gauge) ...	246	248	236
Pressure in nozzle box No. 2, lb. per sq. inch (gauge) ...	247	251	60
Pressure in nozzle box No. 3, lb. per sq. inch (gauge) ...	249	—	255
Pressure in first compartment, lb. per sq. inch (gauge) ...	99	82	57

It should be added that in the trial at 18,200 kw. there were 28 nozzles in operation as against 24 in the trial at 15,650 kw., which accounts for the fact that at the two loads there is but little difference in the nozzle box pressures. In the trial at 15,650 kw. the average pressure in the nozzle boxes was about 5·3 lb. less than the stop valve pressure, and hence under the guarantee conditions we may take the mean nozzle box pressure as 260·1 lb. per square inch (absolute) while the total heat H^1 is 749·28 centigrade heat units. Similarly, under the guarantee conditions the pressure in the first compartment may be taken as 94·77 lb. (absolute). It will be seen that a large pressure drop has been allowed at this first stage, with the object (at some sacrifice of efficiency) of restricting high pressures and temperatures to the nozzle boxes.

At the first stage the effective thermodynamic head is the same as the adiabatic heat drop, which for superheated steam is most conveniently deduced from Callendar's equation, viz.:—

$$u = (H^1 - 464)\left(1 - \left(\frac{1}{x}\right)^{\frac{3}{13}}\right)$$

where H^1 denotes the initial total heat and x the ratio of the initial to the final pressure.

In the present case this gives

u = 59·32 centigrade heat units.

The wheel having a mean diameter d of 84 in. and the speed being 1,500 r.p.m. the value of K for this first compartment is

$$\left(\frac{84}{10}\right)^2 \cdot \left(\frac{1,500}{100}\right)^2 = 15,880$$

so that

$$\frac{K}{U} = \frac{15,880}{59{\cdot}32} = 267{\cdot}7$$

Hence from curve, Fig. 1, which is reproduced from our issue of February 3, 1922, the "hydraulic" efficiency of this first stage is 0·615. Actually, owing to windage it will be somewhat less, but it is most convenient to make corrections for windage, leakage, &c., at a later stage, a procedure which the relative smallness of the corrections renders legitimate. Hence the steam as it enters the nozzles of the second stage has a total heat of 712·79 C.H.U.

As a next step let us determine what the hydraulic efficiency of the turbine would be were the saturation line crossed at pressures of respectively 10 lb., 15 lb. and 20 lb. absolute. We have then

p_s	10	15	20
H_s	635·01	639·53	642·82

whilst we have just found H_1 to be 712·79 C.H.U.

Then to determine the efficiency η corresponding to the above alternatives, we employ Callendar's equation

$$\frac{H_1 - 464}{H_s - 464} = \left(\frac{p_1}{p_s}\right)^{\frac{3\eta}{13}}$$

where $p_1 = 94{\cdot}77$ lb. per square inch absolute. We thus find that η would have the following values if the saturation line were crossed at the pressures stated.

p_s	10	15	20
η	0·7223	0·8199	0·9198
u_s (C.H.U.)	104·24	117·43	128·17

To determine the work done if the expansion were continued beyond the saturation line with the same efficiencies, we find first the value of the adiabatic heat drop u_s if the expansion took place in conditions of thermal equilibrium. These values are given above, and to determine the corresponding real thermodynamic head U_s these values have to be multiplied by ψ as deduced from the equation given in the preceding column, or from the alignment chart published on page 129 of ENGINEERING, February 3, 1922.

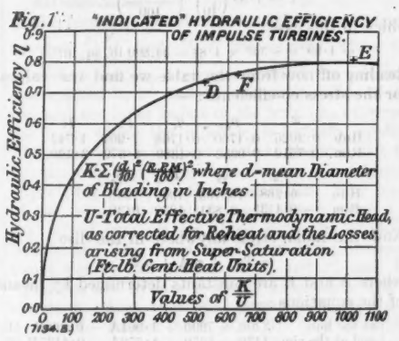
We thus get

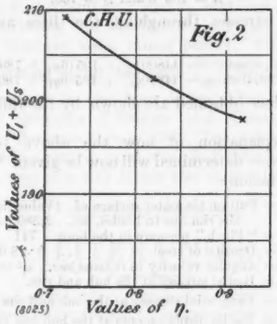
U_s	101·42	113·03	122·03

Similarly we find that U_1, the thermodynamic heads which become available during the expansion from the first compartment to the saturation line, are

$U_1 = \frac{H_1 - H_s}{\eta}$ = ...	107·68	89·35	76·07
$U_1 + U_s$	209·10	202·38	198·10
η	0·7223	0·8199	0·9198
$\frac{K_1}{U_1 + U_s}$	987	1020	1042

The value of K_1 for the turbine, exclusive of the





* See ENGINEERING, vol. cxi, pages 435, 449, 501, 532, 537, 597 and 620.

first stage, is

$$13 \times \left(\frac{84}{10}\right)^2 \left(\frac{1,500}{10}\right)^2 = 206,440$$

Hence from Fig. 1 we see that all three values of $\frac{K_1}{U_1 + U_2}$ given above correspond to a very flat part of the efficiency curve, so that it is evident that an efficiency of 80 per cent. might be expected from this part of the turbine. If we plot down the value of $U_1 + U_2$ against η and draw a curve through the points as in Fig. 2, we find the value corresponding to 80 per cent. to be 203·5 C.H.U., and hence the "indicated" work done per lb. of steam in this part of the turbine is 162·8 C.H.U. Adding to this the work done in the first stage, per lb. of steam passed, we get a total indicated work of 199·2 C.H.U. per lb. of steam. Hence the consumption per "indicated" kilowatt hour is 9·51 lb. as against 10·21 lb. per kilowatt hour as measured at the switchboard. The ratio of "indicated" to switchboard kilowatts is therefore 93 per cent., corresponding to a 7 per cent. loss in the generator and in disc friction, bearing friction and leakage. It is pretty certain that the aggregate of these losses is not materially less than 7 per cent. and this shows very conclusively that the efficiency of the multiple exhaust section cannot be materially different from that of the preceding stages.

It is possible that the efficiency corresponding to the values of $\frac{K}{U_1 + U_2}$ may be as high as 81 per cent., since the point E on curve 1 is particularly well authenticated. If this be so, the aggregate losses in the generator, disc friction, bearings, leakage, &c., would be about 7·7 per cent.; but even so it is very evident that the multiple exhaust section must be highly efficient. It is also possible that the efficiency of the first stage of the turbine has been a little under-estimated, since with the large pressure drop here used, the nozzle efficiency may well be higher than its normal value. A correction for this might bring the difference between the "indicated" and the electrical kilowatts up to a little over 8 per cent. Even this figure, however, is not larger than might well be represented by the generator losses and the "parasitic" losses in the turbine. It is thus evident that the adoption of the "multiple exhaust" has not involved any material reduction in the efficiency of the turbine. Indeed, so far as the tests go they indicate that the efficiency of the last stage is much the same as the efficiency of those preceding it.

ROTATING DISCS OF CONICAL PROFILE.

By B. Hodkinson, B.Sc., A.M.I.C.E.

In Engineering, January 5 and January 26, 1923, Mr. H. M. Martin gave a solution of the previously unsolved problem of the stresses developed in a rotating disc of conical profile. To facilitate use the complicated functions which occur in the solution were tabulated, and after the present writer had drawn attention to a slip in one part of the analysis a corrected table was published in Engineering of May 18, 1923, page 630. This table forms the basis of the practical method of determining stresses in such discs which is described below, and for convenience of reference is reproduced herewith. The solution was based on the same assumptions as that by which the stresses in a hyperbolic disc are determined, and is therefore mathematically just as rigorous, but with the use of the table, involves only a tenth to a twentieth part of the labour and the probability of mistakes. Figures can be rapidly checked, while only slide-rule accuracy is needed throughout. For the hyperbolic disc, since the working is so tedious, various graphs have been devised as aids to calculation, but to get accuracy with these, the boundary stresses, *i.e.*, the radial stress in the disc at the hub and at the rim should be known, otherwise, if a precise result is wanted, the long calculation has to be gone through, and seven figure logarithms will usually be required. And after all, when this has been done, the actual disc will usually be machined conical, and not hyperbolic. With the conical disc too, to get a precise result, the radial stresses near the hub and under the rim should be known, though for rough work, upper limits for the most dangerous stresses can be got, say, by considering the rim as saw-cut into segments and neglecting the shoulders of the hub, *i.e.*, continuing the disc to the bore (though the effect of the hub in reducing disc stress is usually too great to be dismissed so simply), or by other approximate assumptions. But approximations and upper limits do not afford the best basis for the design of rotating discs, where economy of metal is often desirable on many grounds other than the mere cost of the disc.

The aim of this article is to point out that for any given loading the boundary stresses can without any simplification or further assumption, be put in by trial, easily, and with ample accuracy, and thus the complete solution obtained for the practical disc. An example will be worked out for the disc represented in Fig. 1.

The radial and tangential stresses σ_{r_1} and σ_{r_2} near the hub and rim come out, as will be explained later, as 3,200 lb. and 4,430 lb. per square inch respectively. And

$$T = 1{\cdot}99 \left(\frac{D}{10}\right)^2 \left(\frac{R.P.M.}{100}\right)^2,$$

which in this case

$$= 1{\cdot}99 \times 8{\cdot}34^2 \times 1{\cdot}8^2 = 44{,}800 \text{ lb. sq. in.}$$

Reading off now from the table we find the values for the stress co-efficients :—

	x	p_c	q_c	p_1	q_1
Hub	0·3026	0·1760	0·1768	1·904	1·742
Rim	0·7510	0·0952	0·1369	4·579	3·120

	p_2	q_2	Tp_c	Tq_c
Hub	− 6·268	10·769	7900	7930
Rim	− 0·4137	2·831	4270	6130

Now the radial stress anywhere in the disc

$$= Tp_c + p_1 A + p_2 B$$

where A and B are constants determined by means of the equations :—

$$\begin{cases} \text{at the hub} & 3200 = 7900 + 1{\cdot}904A - 6{\cdot}268B \quad (1) \\ \text{and at the rim} & 4430 = 4270 + 4{\cdot}579A - 0{\cdot}4137B \quad (2) \end{cases}$$

$$\therefore A = 105{\cdot}6 \text{ and } B = 780,$$

and the stresses throughout the discs are given as :—

$$\begin{cases} \text{Radial stress} = 44800p_c + 105{\cdot}6p_1 + 780p_2 \quad (3) \\ \text{Tangential stress} = 44800q_c + 105{\cdot}6q_1 + 780q_2 \quad (4) \end{cases}$$

Values thus obtained are shown by the full lines in Fig. 1.

An explanation of how the above boundary stresses were determined will now be given. With the usual notation :

σ_3 = Pull on the outer surface of the rim due to blades, &c. (Value in this case) 2,580 lb. sq. in.
σ_0 = "Pinch" pressure in the bore 711 "
μ = Density of steel .. .. 0·28 lb. cu. in.
ω = Angular velocity in radians/sec. $\omega^2 = 35{,}500$
$\sigma_{r_1}, \sigma_{r_2}$ = Radial stresses at the hub and rim.
$\sigma_{t_1}, \sigma_{t_2}$ = Tangential stresses at the hub and rim.
ξ_1, ξ_2 = Radial displacements at the hub and rim.
E = Young's Modulus. Actual value immaterial.

as given in text books, the total "hoop" stress in the rim due to :

(1) Centrifugal force of the blades. (2) Centrifugal force on the rim itself. (3) Restraint by the disc.

$$= \frac{\sigma_3 x_3}{\delta_3} + \frac{\mu \omega^2 x_3^2}{g} - \frac{y_2 \sigma_{r_2} x_3}{\delta_3 y_3}$$

An explanation of how this is obtained may not be out of place. It is a question of finding the tensile stress f, say, in a hoop of rectangular section, as in Fig. 2, due to a radial pressure of given intensity, say, σ. Dividing the hoop into halves by any diametral plane it will be seen that the loading due to the pressure σ acting all over the upper half is borne by the metal shown in the two shaded areas which are carrying a total load equal to $2fy\delta$. The effect of all the radial pressures σ is the same, as can be seen for example, by the elementary principles of hydrostatics, as a uniform pressure of the same value σ acting all over the plane area A B C D, and therefore equivalent to a total force $= 2xy\sigma$.

$$\therefore \quad 2fy\delta = 2xy\sigma; \quad \therefore \quad f = \frac{x\sigma}{\delta}$$

Now supposing the ring to be the rim of a turbine disc the quantity σ is made up of the pull of the blades, σ_3 per unit area, together with the centrifugal force of the rim itself, $\frac{\mu \omega^2 x_3 \delta_3}{g}$ per unit area, minus the "restraint," *i.e.*, the inward pull of the disc, $\sigma_{r_2} \cdot \frac{y_2}{y_3}$ where the factor $\frac{y_2}{y_3}$ appears because the radial stress σ_{r_2} over a width y_2 is carried by the width y_3 of the rim.

Thus, the hoop stress "f" in the metal of the rim

$$= \frac{x\sigma}{\delta} = \frac{x_3}{\delta_3}\left(\sigma_3 + \frac{\mu \omega^2 x_3 \delta_3}{g} - \frac{\sigma_{r_2} y_2}{y_3}\right)$$

Now the tangential strain at any point in the disc is equal to the radial displacement of the metal divided by the radius at that point $= \frac{\xi}{r}$. But the disc being connected to the rim, their radial displacements must, at their junction, be the same. Therefore the rim "hoop" strain is

Stresses Developed in Complete Double-Conical Disc by Different Methods of Loading.

—	Stresses due to Centrifugal Forces Lb. per Sq. In.		Stresses due to a Pull of 1 Lb. per Inch Run Applied to Knife-Edge Forming Periphery of Complete Disc Lb. per sq. in.		Stress Coefficients due to an Infinite Pressure Applied to the Interior of an Infinitely Small Hole Drilled Through Centre of Disc.	
$\frac{r}{R}$	Radial $p_c = T^* \times$	Tangential q_c $T^* \times$	Radial p_1	Tangential q_1	Radial p_2	Tangential q_2
0·0	0·1655	0·1655	1·435	1·435	∞	∞
0·05	0·1709	0·1695	1·497	1·475	−273·4	288·6
0·10	0·1753	0·1727	1·559	1·518	− 66·62	77·28
0·15	0·1782	0·1752	1·627	1·565	− 28·68	36·55
0·20	0·1794	0·1768	1·707	1·617	− 15·54	21·91
0·25	0·1785	0·1773	1·796	1·674	−9·553	14·88
0·30	0·1761	0·1768	1·898	1·738	−6·371	10·89
0·35	0·1734	0·1758	2·015	1·809	−4·387	8·531
0·40	0·1694	0·1739	2·151	1·890	−3·158	6·915
0·45	0·1635	0·1712	2·311	1·983	−2·328	5·788
0·50	0·1560	0·1676	2·501	2·090	−1·743	4·944
0·55	0·1466	0·1631	2·733	2·217	−1·309	4·301
0·60	0·1355	0·1580	3·021	2·369	−0·9988	3·816
0·65	0·1230	0·1520	3·390	2·556	−0·7523	3·419
0·70	0·1094	0·1451	3·860	2·794	−0·5670	3·102
0·75	0·09558	0·1371	4·559	3·111	−0·4161	2·835
0·80	0·08055	0·1285	5·563	3·557	−0·2971	2·614
0·85	0·06336	0·1189	7·263	4·276	−0·1995	2·421
0·90	0·04425	0·1090	10·620	5·554	−0·1205	2·263
0·95	0·02315	0·0977	20·645	8·890	−0·0555	2·140
1·00	0·00000	0·0890	∞	∞	0	2·051

* $T = 2\left(\frac{D}{10}\right)^2 \left(\frac{R.P.M.}{100}\right)^2$ where D = external diameter of complete disc measured in inches.

Fig. 1.

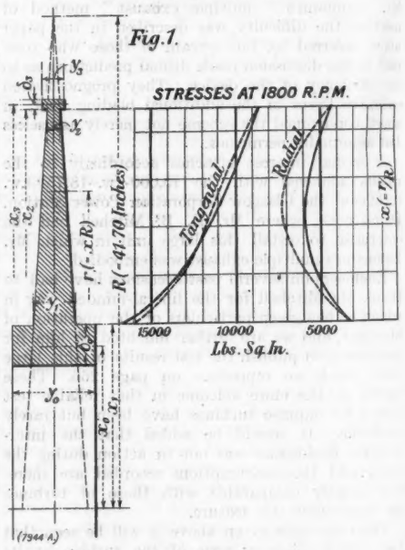
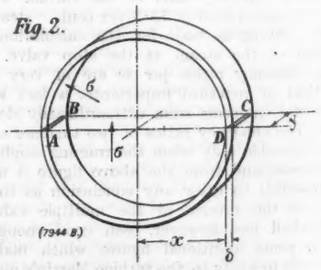


Fig. 2.



equal to the disc tangential strain, which again $= \frac{1}{E}(\sigma_{t_2} - 0{\cdot}3\,\sigma_{r_2})$, where $0{\cdot}3$ = Poisson's ratio.

Multiplying by E and equating to the expression found above for hoop stress gives :

$$\sigma_{t_2} = \left(\frac{\sigma_3 x_3}{\delta_3} + \frac{\mu\omega^2 x_3^2}{g}\right) - \sigma_{r_2}\left(\frac{y_3 x_3}{\delta_3 y_3} - 0{\cdot}3\right)$$

Inserting the dimensions from the drawings gives, in this particular disc :

$$\sigma_{t_2} = 2{\cdot}85 \times 10^3 - \sigma_{r_2} \times 62{\cdot}325 \quad . \quad . \quad . \quad (5)$$

Similarly, in the hub, which again is a ring of rectangular section, the total hoop stress due to :—

(1) "Pinch at the bore." (2) Centrifugal force on the hub itse'f. (3) Pull by the disc.

$$= \frac{\sigma_0 x_0}{\delta} + \frac{\mu\omega^2 x_0^2}{g} + \frac{\sigma_{r_1} y_1 x_1}{\delta_0 y_0}$$

E × (hub strain) $= \frac{E\xi_1}{x_0}$ which also = E × (disc tangential strain) $= \sigma_{t_1} - 0{\cdot}3\,\sigma_{r_1}$.

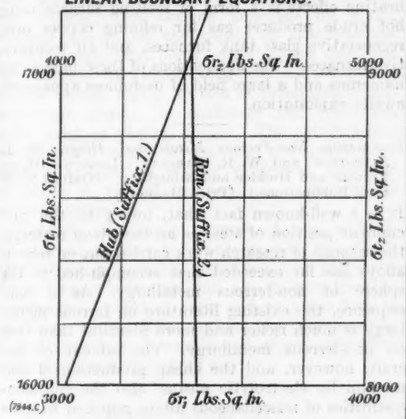
$$\therefore \sigma_{t_1} = \left(\frac{\sigma_0 x_0}{\delta_0} + \frac{\mu\omega^2 x_0^2}{g}\right) + \sigma_{r_1}\left(\frac{y_1 x_1}{\delta_0 y_0} + 0{\cdot}3\right),$$

which, inserting the data from the drawings

$$= 7{\cdot}96 \times 10^3 + \sigma_{r_1} \times 2{\cdot}66 \quad . \quad . \quad . \quad . \quad (6)$$

The problem is to find values of σ_{r_1} and σ_{r_2} which when substituted in the left side of equations

Fig. 3. STRAIGHT LINES REPRESENTING THE LINEAR BOUNDARY EQUATIONS.



(1) and (2) respectively, yield such values of A and B as give tangential stresses (equation 4) which satisfy equations (5) and (6). This is much easier than one might at first expect. It may be helpful to make graphs of the linear equations (5) and (6), (see Fig. 3), when it will be noticed at once that the gradient of σ_{t_2} in terms of σ_{r_2} is so steep ($-62{\cdot}325$) that for any reasonable value of σ_{t_2} to be possible the value of σ_{r_2} is fixed immediately within 1 per cent. or 2 per cent., and can, of course, be adjusted afterwards more closely if desired. Values of σ_{r_1} are now tried, each trial yielding new values of the constants A and B, and by equation (4) a fresh value of the tangential stress near the hub. This substituted as σ_{t_1} in equation (6) should lead back again to the assumed value of σ_{r_1}. In passing, it may be observed, that equation (4) will also give the tangential stress under the rim, and this can at once be used to fix finally the value of σ_{r_2} between close limits. The work is fortunately further made easy by the fact that the arithmetical expressions for A and B have a common constant denominator throughout, *e.g.*, in the present example, the first attempt, they read :—

At the hub :

$$\sigma_{r_1}' = 2650 = 7900 + 1{\cdot}904A - 6{\cdot}268B \quad . \quad . \quad (1)$$

and at the rim :

$$\sigma_{r_2} = 4370 = 4270 + 4{\cdot}579A - 0{\cdot}4137B \quad . \quad . \quad (2)$$

$$\therefore A = \frac{6{\cdot}268 \times 100 + 0{\cdot}4137 \times 5250}{6{\cdot}268 \times 4{\cdot}579 - 0{\cdot}4137 \times 1{\cdot}904} = 100,$$

and

$$B = \frac{1{\cdot}904 \times 100 + 4{\cdot}579 \times 5250}{6{\cdot}268 \times 4{\cdot}579 - 0{\cdot}4137 \times 1{\cdot}904} = 867{\cdot}4.$$

This led to values of the tangential stress which were quite unsuitable as tested by equations (5) and (6), and after two trials the assumed values of the stresses were modified to :

$$\sigma_{r_1}' = 3200 = 7900 + 1{\cdot}904A - 6{\cdot}268B$$
$$\sigma_{r_2}' = 4430 = 4270 + 4{\cdot}579A - 0{\cdot}4137B$$

whence

$$A = \frac{6{\cdot}268 \times 160 + 0{\cdot}4137 \times 4700}{6{\cdot}268 \times 4{\cdot}579 - 0{\cdot}4137 \times 1{\cdot}904} = 105{\cdot}6$$

$$B = \frac{1{\cdot}904 \times 160 + 4{\cdot}579 \times 4700}{6{\cdot}268 \times 4{\cdot}579 - 0{\cdot}4137 \times 1{\cdot}904} = 780$$

This gives, by equation (4) :

$$\sigma_{t_1} = 44800 \times 0{\cdot}1768 + 105{\cdot}6 \times 1{\cdot}742 + 780 \times 10{\cdot}769 = 16514$$

$$\sigma_{t_2} = 44800 \times 0{\cdot}1369 + 105{\cdot}6 \times 3{\cdot}120 + 780 \times 2{\cdot}831 = 8670$$

Putting $\sigma_{r_1}' = 3{,}200$ and $\sigma_{r_2}' = 4{,}430$ in equations (6) and (5) respectively gives :—

$$\sigma_{t_1} = 16470 \text{ and } \sigma_{t_2} = 8700$$

These have therefore been accepted as close enough.

The dotted curves in Fig. 1 show the stresses worked out at length, for the same disc, at the same speed, &c., but with the conical replaced by the hyperbolic profile.

Mathematicians may object that the initial terms in the boundary conditions as above set out ought to read $\frac{\sigma_3 x'_3}{\delta_3}$ and $\frac{\sigma_0 x'_0}{\delta_0}$, respectively, where the symbols x_3 and x_0, the mean radii at rim and hub, are replaced by x'_3 and x'_0, the outer radius of the rim and the inner radius of the hub, *i.e.*, of course, the bore, where the pinch σ_0 is actually applied. This, the writer is inclined to do at the hub, but the alteration is only slight. At the rim the difference is probably never worth consideration. The forms of the boundary equations used above, along with the actual symbols are those given in Stodola's treatment. The quantities involved are obviously two fewer by the absence of x'_3 and x'_0 and the equations are by now probably widely accepted as standard. Also, they give upper, *i.e.*, safe results since x_0 is greater than x'_0. It may be added that the rim strains at x_0 and x_3 have been equated to the disc strains at x_1 and x_2, also that distortions by "crowning" of the hub and rim are neglected ; these, however, seem minor points. The necessity for inserting at all the term $\frac{\sigma_0 x_0}{\delta_0}$ to take care of the pressure in the bore is questionable, *e.g.*, see H. M. Martin's "Design and Construction of Steam Turbines," page 194. The magnitude and importance of σ_0 and the individual discretion of the engineer will decide the matter in particular cases.

LITERATURE.

The Electric Handling of Materials, A Manual in Four Volumes on the Design, Construction and Application of Cranes, Conveyors, Hoists and Elevators. Vol. IV, *Machinery and Methods.* By H. H. BROUGHTON, M.I.Mech.E., M.I.E.E. London : Ernest Benn, Limited. [Price 50*s.* net.]

THE bulk handling of materials at docks and in warehouses, at mines and in workshops, is so important a factor in the economic distribution of those commodities essential to modern life that it deserves consideration as one of the most important subjects dealt with by engineers. Until recently the literature on the subject was scattered through the proceedings of the various institutions, the columns of the engineering press and in some few small works. Mr. Broughton has brought together the information that is available on the electrical handling of materials, added to it from his own valuable experience and presented the whole in a very attractive and systematic way in the monumental work he has written on the subject. The volume recently published is the last of the four, and deals with machinery and methods. The earlier volumes were concerned with electrical equipment, structural steelwork and mechanical equipment, and cranes and crane mechanisms. Now that the work is completed we can gauge the value of the author's painstaking endeavours and estimate the degree of appreciation with which it will be received by the engineering world.

Throughout the work, Mr. Broughton has dealt broadly with the question of design and given a great number of examples to illustrate present-day practice and show the tendency of modern developments. In this, he has not restricted himself solely to dealing with British designs, but has included many examples of American and Continental equipments. Where the engineers of other countries than our own have excelled in dealing with a particular commodity, some examples have been chosen to illustrate their plant. Our kinsmen in Canada have set an example to the world, and one that has deservedly been taken as a model, in the handling of grain, and the Americans have evolved better methods of handling iron ores than are to be found elsewhere.

The conditions under which goods must be handled are so varied that the types of available plant are very numerous. Some are suitable for working at particular angles, others are only successfully employed in lifting or lowering in a vertical direction. Mr. G. F. Zimmer successfully showed the angle ranges for the effective working of the different types of plant in a diagram which he described in our contemporary, *The Electrician*, in December, 1919. That semicircular protractor figure bounded by a vertical diameter and having the name of the type of gear suitable for use between any particular range of angles, indicated against a bracket whose length covered the angle range, is very useful in giving a good general guide in the selection of a system. Mr. Broughton has used this diagram as the starting-point in his treatment of the various systems of working.

Elevators of the chain and belt type are provided with brackets of which the size, shape and pitch are determined by the consideration of the rate of feeding and the dimensions and properties of the material. The rates of working vary over a wide range from about 100 ft. per minute with coke to 600 ft. per minute for heavy grain. To obtain the suitable speed of 20 r.p.m. to 40 r.p.m. for the head shaft a double reduction gear drive from the motor is desirable. The author favours the use of a silent chain drive for the first reduction, followed by the use of machine-cut helical gearing. Rigid arm and swing tray elevators are useful in the handling of containers and of them many examples are shown.

The advantage possessed by the system of conveyors in use in handling grain at a port is obvious to all, but many are blind to the great gains obtainable on the application of the system to the smaller duties in works. As a common experience the capital expenditure on such equipment is wiped out in a very short time by the saving in wages. Malleable cast-iron roller chains or for heavy service those of the steel bushed type, are used at each side, for the propulsion of the apron built up from flat or curved steel plates or wooden flights. When the angle of operation is greater than the angle of repose of the material, in the case of delivery to a lower level a retarding type of conveyor makes it possible to work the motor as a generator and thus obtain the advantage accruing from the fall of the material. In many cases one end of the conveyor acts as a retarder, while the other end needs power. Gravity roller conveyors are of great service in handling cases or crated goods. They are portable, and the coupling of bend units with straight runs enables the goods to be deposited in any suitable position in the store. Bucket conveyors with cam trips are much used in the storage of coal and its delivery to hoppers. A form of conveyor which admits of a great amount of flexibility in arrangement is that in which an endless belt is used to carry the material on horizontal or slightly inclined runs or in combinations of the two. A flat belt is sometimes used, but more commonly it is supported on sets of three or five pulleys mounted at such angles to each other as to convert the belt into a trough. The designs of the skip hoists in use in many industries are given in the volume and their operation discussed.

The electrical handling of coal and iron ore in the United States has been continuously accelerated, until to-day the rapid working with unloaders of 15 tons or 17 tons capacity has caused a reduction in the cost of unloading from 28*d.* to 2*d.* per ton. In this field progress in Britain has not been so marked, and the coal exported from the ports of the United Kingdom is put on board ship by balanced hydraulic hoists or tips. The acceleration of coal handling by the installation of modern electrical

equipment, and the general use of wagons of much greater capacity than is the practice to-day, are reforms which would be of great service in Great Britain. Improved methods would reduce the necessity for the great mileage of sidings and the provision of larger trucks would ensure a more efficient use of them.

In Canada, vessels of 12,000 tons take their grain cargoes to the docks and depart empty within 10 hours of arrival. In 1918–19 the total storage capacity of the 3,777 grain elevators was 221,000,000 bushels, the seasonal output of the dominion being 370,000,000 bushels. The chapters in the book relating to grain handling give detailed information on design, construction and equipment, and the results obtained. Many British ports also have excellent grain-handling facilities, and examples from the Manchester Ship Canal, Hull and Glasgow have been selected by the author for description.

In his conclusion, Mr. Broughton refers to the continued need for improved labour-saving appliances. Britain is third in iron and steel production, and the author of this book considers that it is so because she is third in her methods of production. Even where there is a handicap in the production of raw materials for such an industry as shipbuilding, supremacy has been maintained for this country because of the excellence and speed effected in construction by the adoption of up-to-date methods.

This book must be regarded as a very valuable addition to engineering literature. By bringing together information relating to all the methods of handling goods and showing the differences in practice at home and abroad, Mr. Broughton has rendered a great service. Examples form valuable lessons and those which he has provided may contribute largely to the improvement of the methods of handling of goods and materials for which he hopes. That, after all, was the purpose of writing the book, and if it receives the attention it deserves the author's work will not have been in vain.

Modern Gas Producers. By N. E. Rambush, M.I.Chem.E. London: Benn Brothers, Limited. 1923. [Price 55s.]

Considering the magnitude and continually growing importance of the gas industry, its many applications and its potential wealth, the processes of manufacture, whether chemical or mechanical, have not occupied a large space in modern scientific literature. The references in technical journals, generally limited to the explanation of novel points, are not always satisfying or impartial, and the appearance of a comprehensive work, surveying the means and results of converting solid fuel into a thermally efficient gaseous form, will receive very careful attention. While the variables, inherent in the raw product, that exercise an effect on final results are many, and experiment is difficult and uncertain, vague and mischievous estimates of the value of certain processes are apt to be entertained. Authoritative and exhaustive examination is necessary to determine the limits and the condition under which proposed results can be successfully accomplished, and one of the objects Mr. Rambush had in view in preparing this elaborate treatise, was to exhibit the methods at the command of the gas manufacturer, and to demonstrate the conditions under which each might be pursued prudently and economically.

Within the compass of a comparatively short note, it is impossible to do more than to indicate the general method of treatment, and to give some of the conclusions deduced. The work is divided into four sections, the first entitled "theory," surveys the main factors that operate and limit gas producer practice. From this section may be learnt how varied is the list of materials that are, or can be, used in gas manufacture, and how materially they differ in constituents, in moisture content, and in other ways that effect gasification efficiency. Gas making processes may profitably use any combustible matter from anthracite to cherry stones in a suitably designed gas producer, but to obtain gas of the highest thermal efficiency with the economic recovery of by-products, a tolerably uniform fuel of known constituents is necessary. The author contemplates severe competition in the future between the recovery and the non-recovery gas-producer plants, and in this section he enters very fully into the conditions that effect the commercial production of ammonia, hydrocarbonates, carbohydrates, and of sulphur. It looks a comparatively simple problem to make the nitrogen in the air-blast combine with the hydrogen formed by the reduction of the steam, but commercially the scheme has not proved successful, and consequently, the determining factor in the recovery of ammonia rests on the amount of nitrogen in the fuel itself, and if this be bituminous coal, as is usual in this country, analyses shows that the percentages can vary greatly. The effects of the temperature of distillation and of gasification are discussed carefully, and useful rules are submitted that will be accepted, or may serve as a basis for proposed improvement.

The quality and quantity of tar oils and other bodies derivable from the volatile constituents of a fuel depend on so many variables, as the character of the fuel, the temperature to which the material is raised, the duration of exposure, the manner of treatment generally, that it is impossible to lay down fixed rules for guidance, and the practice of making distillation tests should not be abandoned, though the differences between laboratory and commercial tests may make the deductions somewhat untrustworthy. The yields of acetic acid, aldehyde, and ketone, do not vary to the same extent as those of tar, but have not the same commercial importance. The minimum quantity of volatile matter that would justify an attempt to recover tar as a by-product is 15 per cent. of pure coal substance, but with over 25 per cent. recovery should be carried out. As is well known, low temperature carbonization produces tars of less value, owing to the absence of aromatic constituents. The recovery of sulphur is technically possible, from the gypsum, pyrites, iron sulphate, &c., mixed with coal, but the operation is of doubtful utility from a commercial standpoint.

The second and by far the largest section entitled, "Plant," deals with the construction and arrangement of generators and plant, evolved by the success that has followed Dr. Mond's experiments, which have established the value of producer gas as a fuel, with the further prospect of furnishing nitrogenous fertilisers in quantities sufficient to revive our decaying agricultural industry. The author has ably fulfilled his intention of describing the more interesting features of each generic design, that has been constructed and worked to obtain producer gas. He has not limited himself to the production of those types which have proved themselves commercially successful, but special designs which have not been generally adopted in practice have received due attention. Three main sections deal respectively with gas-producer types: gas cleaning and cooling plant types: and machinery and apparatus for causing gas-flow. Each of these sections has many subdivisions, but the mass of detail and the exhaustive treatment make any particular reference impossible. It must suffice to say that this book will long prove a standard work of reference on all matter connected with generator construction and design. The excellent illustrations well supplement the letterpress.

The third section on control testing and analysis in gas-producer plants is comparatively short, for the author purposely excludes from consideration those analytical methods that are to be found in chemical text-books on industrial testing, and strictly limits himself to those points that are of specific importance to the user of a gas-producing plant. Some of these tests may be needed only under exceptional circumstances, and others very occasionally, but these have been included with the intention of covering the whole subject completely. In close connection with the foregoing arise the material questions of working costs and of operating principles. Some chapters are added on these routine matters, into which Mr. Rambush has incorporated much of his acquired experience. He may be assured that we acquit him of any conscious bias or preference towards those plants and methods with which he has been connected or associated during his professional career.

The last section on the practical applications of producer gas for heating and for power purposes, should prove interesting to many to whom the technology of gas production does not appeal. Present achievement and the prospect of wider application may easily excite the attention that is denied to the invisible agent, that by moving turbines and operating machinery provides new impetus to industry. The function of the gas is two-fold: as a power plant familiar in various forms of internal-combustion engines, and as a heat agent. In the former capacity its value is fully recognised, but its application as a heat agent is not so generally practised, because its efficiency varies in accordance with the manner in which the heat is applied, and special requirements have to be met if the best results are to be attained. In operating as a power plant, Mr. Rambush offers some useful criticisms on the way in which gas engines are used, comments favourably on the Humphrey pump, and supplies very useful information concerning the progress made in the application of the gas turbine. The Thyssen Company of Muhlheim has apparently made substantial progress with large units, and it is announced that the metal employed in these Holtzwarth turbines is capable of withstanding the effect of the impinging hot gases on the blades. The gases in the turbine wheel having an average temperature of 400°—450° C., while the maximum may exceed 1,000° C., evidently introduce very great difficulties, but it seems these have been overcome, and it is expected that the efficiency in the newest construction will approach that of the gas engine. Among the more interesting applications of the heating effects is a form of melting furnace using hot crude producer gas for refining copper ores, regenerative glass tank furnaces, and air recuperative furnaces. The applications of these models are numerous and a large field of usefulness apparently awaits exploitation.

Engineering Non-Ferrous Metals and Alloys. By L. Aitchison and W. R. Barclay. London: Henry Frowde and Hodder and Stoughton. (Oxford Technical Publications.) [Price 21*s.* net.]

It is a well-known fact that, owing to the pre-eminent position of steel as an industrial material, the amount of research work carried out on ferrous alloys has far exceeded that accomplished in the sphere of non-ferrous metallurgy. As a consequence, the existing literature on ferrous metallurgy is much richer and more plentiful than that on non-ferrous metallurgy. The advent of aircraft, however, and the cheap production of aluminium by electrolytic means, also the enormous quantities of miscellaneous alloys required to meet the demands of the services during the Great War, served to focus the attention of the entire engineering world upon the non-ferrous industry.

In the above work Messrs. Aitchison and Barclay have endeavoured to provide both those who make and those who use the non-ferrous metals with some fundamental information on the subject. The book is divided into two parts, the first dealing with non-ferrous metals quite generally, and the second with the individual metals and alloys in some detail. The authors open with a brief account of cooling curves, thermal equilibrium diagrams and the micro-constituents of binary and ternary alloys. Theoretical considerations on the above subjects seem specially written for engineers whose time, for this branch of study, is limited. A very important section on casting follows. The fact that the production of sound ingots and castings is a matter of great importance, not only to the maker, *i.e.*, the metallurgist, but also to the user, *i.e.*, the engineer, is insisted upon at the outset. The theoretical side of the question is exhaustively dealt with and some sound practical advice given on such subjects as the preparation of moulds. The sections dealing with the working, heat treatment, mechanical properties and testing of non-ferrous materials will appeal to engineers. The authors refrain from mentioning any particular alloy, they limit themselves to discussing the general principles involved. They also make the most of the space at their disposal, much useful ground being covered in a relatively small number of pages. A good instance of this is shown in Chapter V, where the advantages secured by heat treating non-ferrous alloys are stated simply and succinctly without lengthy arguments. The value and limits of various mechanical tests are well shown. The remarks

on fatigue will be found very helpful and constitute possibly the most interesting section of a highly useful chapter.

Part II. is encyclopædic in character, the subject being divided into (1) Copper and Alloys of Copper, (2) Aluminium and its Alloys, (3) Nickel and its Alloys, and (4) Miscellaneous Non-Ferrous Alloys. The classification adopted for the numerous copper alloys is ingenious. These are divided according to their maximum stress value (in the "as cast" condition), this being considered to be the fundamental requirement of the engineer. The general, physical and chemical properties of each series of alloys are then discussed separately, the authors striving to give engineers all available information. The numerous tables will be found particularly useful when fixing specifications. The section devoted to aluminium is excellent and the classified information given on alloys of that metal is admirably well set out. Especially interesting are the authors' remarks on the corrosion of aluminium and the light alloys. The increasing importance of nickel alloys, in spite of their relatively high cost, is pointed out in the section devoted to nickel. The nickel-chrome alloys are shown to be particularly valuable on account of their high specific resistance and also because of their ability to withstand corrosion. The nickel-silvers and the cupro-nickels are also well described. The section on miscellaneous non-ferrous alloys deals chiefly with bearing metals, tin-base and lead-base white metals, and solders. The authors conclude by giving valuable advice on the choice of specifications. They maintain that many materials are employed for purposes for which they are not eminently suitable owing, partly, to lack of systematic knowledge and, partly, to traditions and prejudices which exist in various trades. The specifications recommended might be described as being a tabulated recapitulation of the properties possessed by alloys of various compositions dealt with in earlier chapters.

Evidently the whole purpose of the book is, not only to provide the engineer with as reliable information as possible regarding the properties of non-ferrous materials, but also to give him the metallurgist's point of view and to assist him to appreciate to the fullest extent the true meaning of the properties of metals and alloys, and their relative values in industrial use.

BOOKS RECEIVED.

Practical Control of Electrical Energy. By A. G. COLLIS. London: Henry Frowde and Hodder and Stoughton. [Price 10*s.* 6*d.* net.]

Department of Overseas Trade. Report on the Commercial and Industrial Situation in Hungary. By R. J. E. HUMPHREYS. London: H.M. Stationery Office. [Price 1*s.* 6*d.* net.]

Department of Overseas Trade. Report on the Industries and Commerce of Spain. By Captain U. de B. CHARLES. London: H.M. Stationery Office. [Price 2*s.* net.]

Department of Overseas Trade. Report on the Economic and Financial Situation of Egypt. By E. H. MULOCK. London: H.M. Stationery Office. [Price 1*s.* 6*d.* net.]

London Shipping. Who's Who? 1923. Liverpool: The Journal of Commerce. [Price 2*s.*]

Liverpool Shipping. Who's Who? 1923. Liverpool: The Journal of Commerce. [Price 2*s.*]

North East Coast Shipping. Who's Who? 1923. Liverpool: The Journal of Commerce. [Price 2*s.*]

Scottish Shipping. Who's Who? 1923. Liverpool: The Journal of Commerce. [Price 2*s.*]

Small Electric Lighting Sets. By Lieut. C. F. CAUNTER, R.E., Glasgow: James Munro and Co., Limited. [Price 3*s.* 6*d.* net.]

Die Dampfturbinen, Ihre Wirkungsweise Berechnung und Konstruktion. II. Die Berechnung der Dampfturbinen und die Konstruktion der Einzelteile. By Professor CONST. ZEITEMANN. Berlin und Leipzig: Walter de Gruyter and Co. [Price 1*s.*]

Die Linienführung der Eisenbahnen. By H. WEGELE. Berlin und Leipzig: Walter de Gruyter and Co. [Price 1*s.*]

Heizung und Lüftung. II. Ausführung der Heizungs und Lüftungsanlagen. By JOHANNES KÖRTING. Berlin und Leipzig: Walter de Gruyter and Co. [Price 1*s.*]

Oil Flow Viscosity and Heat Transfer. By R. S. DANSFORTH. San Fransisco: R. S. Dansforth, 525, Market-street. [Price $2.]

La Réception des Combustibles Liquides. (Fuel Oils and Gas Oils.) By CAMILLE DENIER. Paris: Étienne Chiron. [Price 12 fr.]

Proceedings of the American Society of Civil Engineers. Vol. XLIX. No. 6, *August*, 1923. New York: Offices of the Society, 33, West 39th-street.

Transactions of the Institution of Civil Engineers of Ireland. Vols. XLVII, XLVIII, 1920–21, 1921–22. Dublin: John Falconer, 53, Upper Sackville-street.

The British Acetylene and Welding Handbook. Prepared by a Committee of the British Acetylene and Welding Association. London: The Acetylene and Welding Journal. [Price 7*s.* 6*d.* net.]

Notes on the Identification of Timbers in Southern India. By R. B. ROBINSON. Technical Paper No. 234. Calcutta: Superintendent Government Printing, India. [Price 8 annas.]

Transactions of the American Institute of Mining and Metallurgical Engineers. Vol. LXVIII. New York: Offices of the Institute.

United States Bureau of Labor Statistics. Bulletin No. 333. *Proceedings of the Ninth Annual Meeting of the International Association of Industrial Accident Boards and Commissions. Baltimore, Md. Oct.* 9–13, 1922. Washington: Government Printing Office. [Price 35 cents.]

United States Bureau of Mines. Bulletin No. 204. *Underground Ventilation at Butte.* By D. HARRINGTON. [Price 25 cents.] Technical Paper No. 339. *Coal-Mine Fatalities in the United States*, 1922. By Wm. W. ADAMS. [Price 10 cents.] No. 340. *Production of Explosives in the United States during* 1922. *With Notes on Mine Accidents due to Explosives.* By WM. W. ADAMS. [Price 5 cents.] Washington Government Printing Office.

INDUSTRIAL NOTES.

THE quarterly report for the period from April 2 to June 30, recently issued by the Associated Blacksmiths' and Ironworkers' Society, says that at the moment of writing the only people who are doing a little are the wagon builders; in some centres the men in this industry are working double shifts. As for shipbuilding, the position is extremely bad. The Board of Trade figures for July gave the export value of ships at 54,955*l.*, as against 3,729,494*l.* for the same period last year. The membership of the Society stood at 13,809, a decrease of 570 compared with last quarter. The total income for the quarter was 26,653*l.*, including 18,752*l.* from the Ministry of Labour, and 1,818*l.* from the Board of Health. The expenditure was 31,843*l.*, including 18,851*l.* for State Unemployment, Dependants and Administration expenses, and 1,821*l.* State Health Insurance Benefits and Administration expenses.

Discussion in the matter of the boilermakers' dispute still continues. The Boilermakers' Society state that it was in February that they ceased to form part of the Trades Federation, when they broke off joint negotiations with the employers and the other trades on the night-shift and overtime agreement, and not on May 17, which was merely the date of the annual meeting of the Federation. In answer to this, the employers state they were informed by the Federation of Engineering and Shipbuilding Trades that when the agreement was signed, on March 22, it was signed on behalf of all the members of the Federation, including the Boilermakers' Society and therefore at that date there was no doubt that the Boilermakers' Society were recognised as members of the Federation. The employers were officially informed by the Federation that the Boilermakers' Society were expelled from membership on May 17, and that from this latter date the Federation could take no further responsibility with regard to the Boilermakers' attitude towards the agreement. There was no intimation that the Society had ceased to be a member of the Federation in February. There is still little hope of a settlement. The executive of the Society met the Trades Federation at York on Wednesday, but after four hours' negotiation no agreement was come to.

There is as yet no settlement in the matter of the railway shopmen on the Great Northern section of the London and North Eastern Railway. It will be remembered that this is a difficulty which has arisen among the unions, the National Union of Railwaymen insisting upon the application to the shopmen of the award 728 of the Industrial Court, whilst the craft unions oppose it. A meeting of the unions was held at the Ministry of Labour at the end of last week. At the close Mr. Frank Smith, speaking on behalf of the craft unions, said they had been unable to agree. The craft unions were taking up the position that they had no grievance and no dispute with the company with regard to the shopmen on the Great Northern section, and did not desire the award to be applied. There was not a single craft union that had made application for the award to be operated; on the contrary, there was conclusive evidence that the craft unions were one and all opposed to it. In the circumstances, they did not feel that any useful purpose would be served by continuing the discussion. The Ministry of Labour had intimated that it would make further efforts to bring about adjustment of the differences, but so far as the award was concerned the attitude of the craft unions was definite and unalterable. Mr. J. H. Thomas, M.P., speaking for the National Union of Railwaymen, said they attended the conference at the invitation of the Minister of Labour. Sir David Shackleton informed them that he was still endeavouring to bring about a settlement, and the National Union of Railwaymen had agreed to leave the matter entirely in the hands of the Minister of Labour to give effect to his promise to endeavour to discover a basis of agreement. This promise was responsible for the temporary suspension of the strike notices.

Canal boatmen, to the number of several hundreds, have gone out on strike as a protest against reduction in tonnage rates. All attempts at negotiation have, so far, been of no effect. The boats on most of the inland waterways are standing idle.

The American journals announce that in the middle of the current month, definite steps were taken in the large iron and steel works of the United States to eliminate the 12-hour shifts and replace them by three shifts of 8 hours each. Dealing with some works, the *Iron Age*, New York, says: ". . . . The hourly wage of common labour on the 8-hour shifts has been advanced 25 per cent., or from 40 cents to 50 cents. This will mean a daily wage of 4 dols. as compared with 4.80 dols. for a 12-hour turn. A considerable number of men have expressed a desire to work two 8-hour shifts, but this will not be permitted by the management." This last statement as to the wish of the men to work longer hours than 12 is most significant.

A Bill was passed in Holland, on May 4, containing regulations for furthering the peaceful settlement of labour disputes and for preventing such disputes. The Act rejects the principle of compulsory arbitration, and relies chiefly in conciliation and in influencing public opinion by the publication of the facts of the disputes and the decisions of the various conciliation and arbitration bodies. It provides for four agencies in the process of State mediation: (*a*) The State Conciliator; (*b*) the Conciliation Council; (*c*) the Arbitration Court; and (*d*) the Committee of Inquiry. A State Conciliator is appointed by Royal decree for each district; when a dispute occurs involving at least 50 workers, the Burgomaster notifies the State Conciliator immediately, giving him information enabling him to judge of the cause, extent and probable consequences of the dispute. The Conciliator may recommend the parties to apply for the appointment of a Conciliation Council or, if this latter is unsuccessful, to submit the dispute to an Arbitration Court. In a dispute which may seriously affect the interests of the community and in which at least 300 workers are involved, if all the previous means have failed, a Committee of inquiry may be appointed. This committee may subpœna witnesses and experts, who are obliged to appear and furnish the information required. For the prevention of disputes, a clause provides that on the request of the employers and workers the State Conciliator may assist in concluding labour agreements if these are likely to promote good relations between employers and workers and prevent disturbances of work

During the quarter ended March 31 the amount of saleable coal raised in Great Britain amounted to 67,077,543 tons; the quantity disposable of commercially was 61,335,892 tons, of which 23,262,722 tons were shipped. The net costs of production were 50,663,203*l.*, equal to 16*s.* 6·24*d.* per ton disposable commercially, in which wages entered for 35,441,768*l.*, or 11*s.* 6·68*d.* per ton disposable commercially. The proceeds of commercial disposals amounted to a total of 58,156,716*l.*, equal to 18*s.* 11·56*d.* per ton, showing a credit balance of 7,493,513*l.*, or 2*s.* 5·32*d.* per ton. The total number of workpeople employed was 1,087,733, the average output per man-shift worked being 18·25 cwt., and the average earnings per man-shift worked 9*s.* 7·72*d.*

Trouble has arisen among the municipal employees in London, both unskilled and semi-skilled men, in regard to the sliding-scale agreement, which the men, we understand, wish to have terminated. They also oppose the working of the cost of living index figure as drawn up by Government. The unions involved are the Municipal Employees' Association and the Federation of General Workers.

NEW DOCKYARD WORKSHOPS, STOCKHOLM.—The Swedish naval department has now completed plans for the removal of the workshops and other buildings from their present locality at Galärvarvet to a site acquired in the Djurgard district which it is proposed to further extend by the purchase of additional areas. The cost of the removal is estimated at 8,825,000 kr., to off-set which there should be a sum of 7,600,000 kr. which the naval department expects to realise by the sale of the present site. In addition there is a dockyard building fund which it is calculated will amount to 1,300,000 kr. at the end of 1923. These two consequently together provide a sum of 8,900,000 kr. which should more than cover the cost of removal.

INTEGRATING COAL METER.

The annexed illustrations, Figs. 1 to 4, are of a small coal meter which is being put upon the market by Messrs. George Kent, Limited, 199 to 201, High Holborn. The drawings and photograph are practically self-explanatory, the meter consisting of an ordinary counter gear calibrated to cubic feet of coal and driven by a propeller or helix which is inserted in the trunk leading from the hopper to the furnace. The helix is flexibly connected by a double swivel with a spindle, which is mounted in double ball bearings at the lower end of a bent tubular casting projecting into the trunk. This spindle is connected with the counter by means of a flexible shaft. The whole of the gear inside the hollow casting is protected by a number of compressed felt washers which effectually exclude dust from the coal, and provision is made for lubricating the bearing from outside. A detail of the bearing and washer protection to an enlarged scale is given in Fig. 4. It will be seen that the whole of the apparatus, including the helix, can be readily withdrawn for inspection, &c., by the removal of four bolts.

The accuracy of this little instrument is within 2 per cent. or 3 per cent., this being the case we understand even when the size of the coal varies to a considerable extent. The weight can be readily obtained by multiplying the meter reading by the weight per unit volume of material, though the meter can be calibrated direct in lb. if desired. The machine is suitable for grain, cement and other materials, provided that it fills the pipe and falls under its own weight. Correct indication depends upon the size of the chute, the rate of movement and the average size of the material, and gears have to be calculated accordingly. The instrument should be installed at a point where it is possible to arrange for a length of parallel pipe below the bottom of the meter, of at least two pipe diameters. This little instrument will be on view at Messrs. Kent's stand at the Shipping, Engineering and Machinery Exhibition opening to-day.

NOTES ON NEW BOOKS.

A most significant fact in many respects is that the schoolboy of to-day can extemporise for a few shillings an effective wireless receiver, whereas the difficulty of detecting waves was very great at the time of Hertz' experiments in the late 'eighties of last century. This came to our mind when reading the French book *Radio-Télégraphie-Téléphonie-Concert*, by Professor E. Reynaud-Bonin, Paris, a book the main object of which is to assist amateurs to build and to understand the working of their receiving sets, and to explain the difficulties to be overcome in order to secure good reception. After a brief historical review, the author discusses the methods by which wireless waves are produced, the aerial, the earth arrangements required, and the occurrence and effects of "static." Reception is then treated at greater length and a few circuits are described in detail; the modes of functioning of the crystal and valve as detectors are explained, also the use of the valve as amplifier and for producing continuous waves. The resistance and transformer methods for coupling valves amplifying at high frequence are described, but not the tuned anode method; at a later stage it is stated that the resistance couplings are preferably replaced by self-inductances in order to receive the 450 metre waves of the Ecole Supérieure d'Electricité; the actual dimensions of the coils are given, but no mention is made of tuning. On page 87 there seems to be a misprint in the number of turns on the secondary of the H.F. transformer for the range 180 m. to 350 m. where, presumably, 50 is meant instead of 5. The book then gives a short account of the stations transmitting in France which the amateur may receive; some chapters are devoted to radiotelephony, giving notes on the selection of a microphone and on the method of operation of some of the better-known loud-speakers. A number of appendices cover various quantity tables, the abstract of a paper by Mr. Alexanderson, read at Schenectady, on the relation between wave-length and carrying power, and various French State regulations for wireless installations. The cost of the book is 10 francs and it is published by Messrs. Gauthier-Villars et Cie., 55, Quai des Grands Augustins, Paris.

In view of the fact that oil fuel is now used for steam generation in over 3,000 merchant vessels with a total tonnage of nearly 16,000,000, as well as in the greater part of the world's warships, it is not surprising that a number of books on marine oil-burning equipment have made their appearance. Some of them treat the subject historically, describing obsolete systems at length, while others are compiled mainly from makers' catalogues. Neither type of book, of course, is of much value to the sea-going marine engineer. The greater part of a work entitled "*Oil Fuel Burning at Sea and on Land*," by Mr. J. S. Gander, on the other hand, is based upon the author's personal experience of oil-burning practice in all classes of vessels and has been written with the object of placing the information obtained in this way at the disposal of marine engineers and others interested in the combustion of fuel oil. After a few brief chapters on the origin, geology and chemistry of fuel oil, the author describes modern methods of oil burning, dealing with general principles and describing the various systems in use in detail. This section of the work is very fully illustrated and it contains some examples of land installations as well as of marine types. Later chapters deal with the installation of an oil-burning system, the arrangement of bunkers, fire and safety arrangements, auxiliary plant for oil burning, and many other matters of interest and importance. Among the latter may be mentioned a chapter describing the routine procedure during a voyage on oil fuel using the pressure-jet system. This chapter contains much information of a practical nature intended particularly for marine engineers new to the use of oil fuel. A brief chapter towards the end of the book deals with the application of oil fuel to industrial furnaces and to land boilers, but, in general, the book appears to us to be of much greater service to the marine engineer than to the land user of oil fuel; the needs of the latter might well be catered for in a separate volume. Mr. Gander's book is published by Messrs. James Munro and Co., Limited, Glasgow, and its price is 15*s.* net.

In a paper which he read in 1921 before the Sheffield Association of Metallurgists and Metallurgical Chemists, Sir Robert Hadfield pointed out very forcibly that, in metallurgy, Germany had not done much original work, but had been very diligent in applying the fundamental discoveries made in other countries. German readers of the "*Hilfsbuch für Metalltechniker*," by Herr Georg Buchner, published by the Verlag von Julius Springer, Berlin, will hardly be of the same opinion. The book cites mainly German journals and publications; when reference has to be made to a publication in the English language, a journal issued in the United States is very frequently selected. Thus, for example, the book refers to the "observations made by J. H. Whiteley and Stead to the effect that the repeated heating and quenching of a steel cylinder led it to assume a spherical shape." In regard to this, *The Iron Age*, New York, 1918, page 1256, is cited. The point formed the subject of a paper read before the Iron and Steel Institute at the Autumn meeting of 1918, by Mr. J. H. Whiteley, Dr. Stead being the only member who remarked upon it at the meeting. In the section on cast iron, in the matter of tests and grain size, it is said that "new researches by W. Rosenhain and D. Hausen (read Hanson) confirm this" (the author's remarks). Here again *The Iron Age*, New York, is referred to. The Iron and Steel Institute and the Institute of Metals appear to be completely ignored. The alloy "Invar" is dealt with; the journal *Das Metall* is mentioned as the source of information, and no reference made to C. E. Guillaume, its discoverer. Micro-sections are given, taken from "Brearly-Schäfer" (instead of Brearley), on "Tool-steels." We believe Herr Schäfer to have been the translator of Mr. Brearley's book under that title. The name of a French experimentalist is even germanised into Nikolardot, although a few lines lower down it is correctly spelt. There are a few particulars on stainless steel, but no reference to Mr. Brearley's name, only to German ones. The mistakes in the spelling of proper nouns form another remarkable feature of the book, since one thing the Germans can do is to commit proper nouns to memory and repeat them by rote. The book is quoted 10*s.* To our mind it appeals exclusively to German readers, and these are perfectly aware that in the bibliography of papers read before the two British institutes above named, careful reference is made to work carried out by researchers throughout the whole world, when such work is extant.

Imperial Trade Correspondent at Bulawayo.—The Department of Overseas Trade notifies that the address of the Imperial Trade Correspondent at Bulawayo is now as follows:—Mr. F. Fisher, P.O. Box No. 748, Bulawayo.

Personal.—On and after September 1, 1923, the address of the Liverpool Engineering Society will be 9, The Temple, Dale-street, Liverpool.—The Continuous Reaction Company, Limited, a constituent company of Nobel Industries, Limited, who, until recently, had offices at 155, Church-road, Battersea, S.W.11, have now removed these offices to Newton Works, Hyde, Cheshire, to which all correspondence should be sent.

INTEGRATING COAL METER.

CONSTRUCTED BY MESSRS. GEORGE KENT, LIMITED, ENGINEERS, LUTON.

Fig. 1.

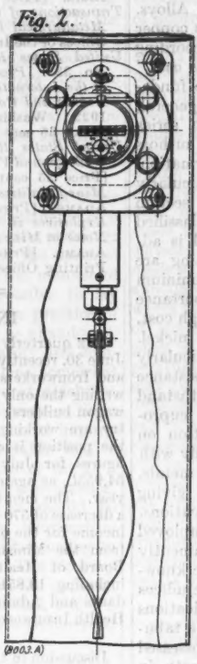


Fig. 2.

Fig. 3.

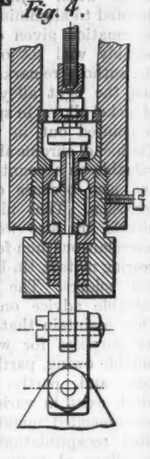


Fig. 4.

HYDRO-ELECTRIC STATION AT CYNWYD, NORTH WALES.

MESSRS. GILBERT GILKES AND CO., LIMITED, ENGINEERS, KENDAL.

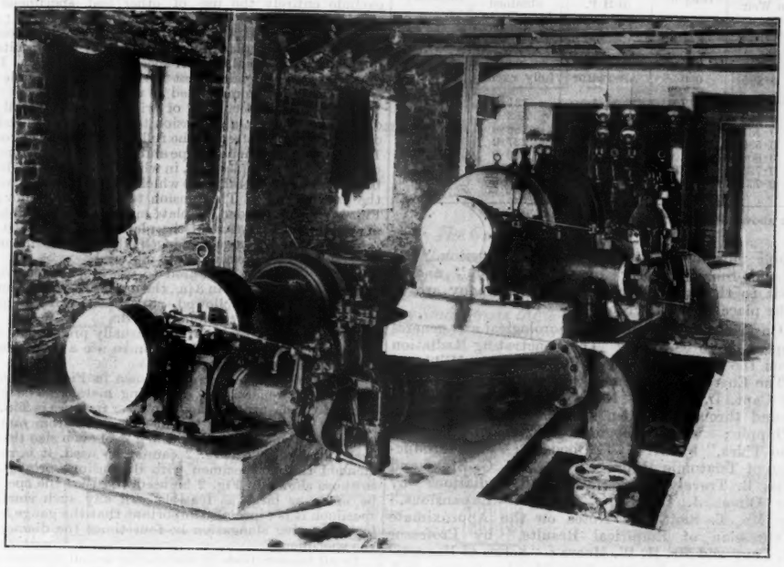


FIG. 1.

FIG. 2.

FIG. 3.

Fig. 4.

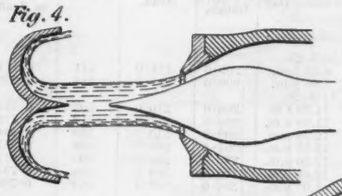


Fig. 5.

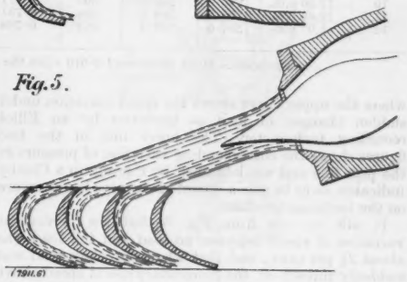


Fig. 6.

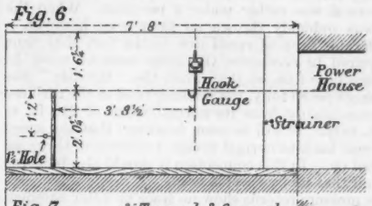


Fig. 7.

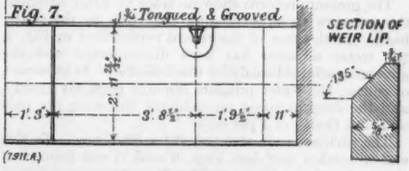


Fig. 8. TEST OF TURBINE N°2950. 21" TURGO IMPULSE. TAKEN AT CORWEN 11.5.23. MEAN HEAD 210'.0"

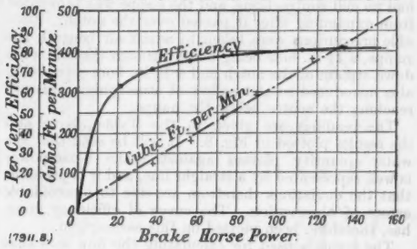


Fig. 9.

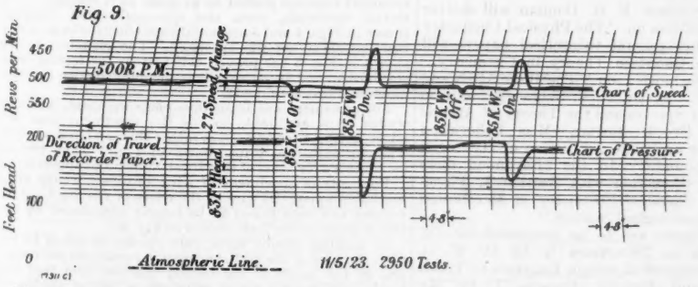
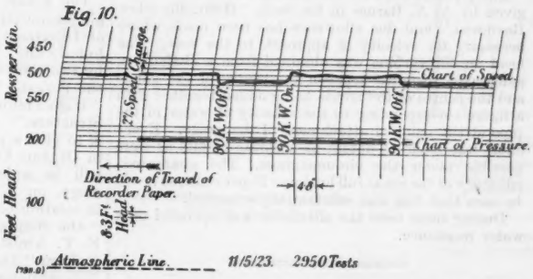


Fig. 10.



MESSRS. GILBERT GILKES AND CO., LIMITED, of Kendal, have recently constructed a small hydro-electric plant for Colonel R. Vaughan Wynn, near the village of Cynwyd, on the Trystion stream, where an impounding reservoir has been constructed holding rather over 1,000,000 cub. ft. of water. A line of 18-in. riveted steel pipes 1,600 ft. long connects the reservoir with the power-house, a view of which is represented in Fig. 1. The working head available here is 210 ft. There are two turbines, both of Messrs. Gilkes' "Turgo" pattern, the larger being 21 in. in diameter and the smaller 12 in. The former is capable of developing 150 b.h.p., and the latter 27 b.h.p. These are direct coupled to alternators supplied by the Brush Electrical Engineering Company, of Loughborough, the larger unit being rated at 112·5 k.v.a. and the smaller at 20 k.v.a. The current generated by the larger of these units is at 3,300 volts, whilst the smaller furnishes current at 400 volts, a step-up transformer being in this case interposed between the alternator and the transmission line.

The turbines have cast-iron runners, views of which are represented in Figs. 2 and 3. The nozzles are of the Pelton type, but the makers state that whilst as simple as the Pelton wheel, the turbines have a higher specific speed. In this installation the larger machine runs at 500 r.p.m., and the smaller at 1,000 r.p.m. The main distinction between the "Turgo" and the Pelton wheel will perhaps be made clearer by a reference to Figs. 4 and 5, where the characteristic differences are very well brought out. In the case of the "Turgo" wheel, Fig. 5, the jet, it will be seen, impinges on the one side, whilst in the case of the Pelton wheel, Fig. 4, the axis of the jet lies in the plane of the wheel.

Special attention has been paid to the matter of governing. Each turbine has a shaft governor operating a deflector, combined with an overtaking gear which on a sudden change of load gradually varies the quantity of water passing through the nozzle. The high standard of regularity attained is strikingly demonstrated by the charts reproduced in Figs. 9 and 10,

TABLE.—Efficiency Tests of Impulse Water Turbines.

No. of Test.	Time of Day.	Head on Gauge.	Corrected Head.	R.P.M.	Head on Weir as Read.	Corrected Head on Weir.	Kilowatt Output.	Corresponding B.H.P.	Corrected Quantity of Water obtained from Curve.	Per Cent. Efficiency.
	10–5–23									
1	6.52 p.m.	209·0	211·0	511	0·114	0·104	0·0	Alternator	unexcited	—
2	7.05 p.m.	209·0	211·0	518	0·208	0·295	0·0	Alternator	fully excited	—
	11–5–23									
5	11.30 a.m.	208·0	210·0	503	0·345	0·337	21·2	37·1	131·0	71·2
6	11.36 a.m.	209·0	211·0	512	0·272	0·262	10·0	20·8	83·0	62·8
8	12.30 p.m.	208·0	210·2	509	0·444	0·437	25·0	56·1	188·0	75·0
9	12.25 p.m.	207·5	209·9	506	0·535	0·530	46·7	72·6	237·0	77·2
10	12.40 p.m.	206·0	208·6	503	0·611	0·608	59·0	89·3	286·0	79·0
11	12.46 p.m.	205·0	208·0	498	0·731	0·732	78·0	117·0	371·0	80·2
12	1.0 p.m.	204·0	207·1	499	0·768	0·771	89·2	132·9	418·0	81·0

Remarks.—Hook gauge read 0·010 when the water above the weir was just level with the sill.

where the upper curve shows the speed variation under sudden changes of load as inscribed by an Elliot recording tachometer. The lower line in the two figures shows the corresponding variation of pressure in the pipe line and was obtained by rigging up a Crosby indicator, so as to give a record of the pipe line pressure on the tacheometer chart.

It will be seen from Fig. 8 that the permanent variation of speed between no load and full load was about 2½ per cent., and that when the whole load was suddenly thrown off, the momentary rise of speed above the normal was rather under 2 per cent. When the load was suddenly thrown on there was, however, a considerable drop of speed due to the fact that time is required to accelerate the large mass of water in the long pipe line, so that when the "throttle" was suddenly opened fully, the working head at the turbines fell momentarily from its normal value of 210 ft. to 120 ft. only. It will be seen, however, that the speed had come back to normal within 3 seconds of throwing the load on. In this connection it should also be borne in mind that no flywheel is used.

The pressure records show no trace of water hammer, the pressure never exceeding that due to the static head. In the case of the record reproduced in Fig. 9, the water adjuster has been disconnected and the governing effected solely by the deflector. In this case, of course, the water pressure remains perfectly steady, and the drop in speed on suddenly throwing the load on is less than ½ of 1 per cent.

The turbines were also tested for efficiency. To this end a wooden box (see Figs. 6 and 7) was formed at the outlet of the larger turbine from the power-house, so as to give a chamber with rectangular sides, and a rectangular notch almost at the end of it. The notch had no end contractions, and the nappe was prevented from expanding after it passed over the notch. Suitable precautions were taken to admit air beneath the nappe, a 1¼ in. hole being bored through the side walls down stream of the notch and a 1¼ in. bore pipe being also introduced so as to allow of atmospheric pressure reaching the centre below the nappe.

The readings are given in the Table above and the results plotted in Fig. 8. It will be seen that the water quantity plotted against brake horse-power is well represented by a straight line, and it is probable that the deviations therefrom are due to unavoidable errors of observation. The curve of efficiency given has, therefore, been plotted on this assumption.

The formula used for calculating the flow was that given by A. A. Barnes in his book "Hydraulic Flow Reviewed," and due allowance has been made where necessary for velocity of approach to the weir. The head on the turbine was obtained from a Budenberg gauge, the distance between the centre of the gauge and the centre of the nozzle being added together with a figure corresponding to the velocity of water in the pipe at the point of attachment of the gauge. Every effort was made to obtain as accurate results as were possible under the circumstances. The guaranteed efficiency of the set at full load was 78 per cent., so it will be seen that this was substantially exceeded.

During these tests the alternator was operated on a water resistance.

THE LIVERPOOL MEETING OF THE BRITISH ASSOCIATION.

In our issue of July 27 we published, on page 114 *ante*, the programme of the Engineering Section G of the British Association which will be opened on Wednesday, September 12. We now give the programmes of two other sections, A and B.

The programme of Section A, Mathematics and Physics, is as follows—on Thursday, September 13, the section will discuss "Cohesion and Molecular Forces" in a joint meeting with Sections B and G; Sir William Bragg is to open the discussion, Dr. Rosenhain will follow on behalf of Section B and Dr. A. A. Griffith on behalf of Section G. The whole morning is left free for this discussion. Dr. W. M. Smart's lecture on "Navigation" and a visit to the Automatic Telephone Company are to take place in the afternoon.

On Friday the following meteorological and general papers are to be read: "The Penetrating Radiation from the Upper Air," by Professor R. A. Millikan; "The Energy of the Circulation of the Atmosphere," by Capt. D. Brunt; "Notes on the Transmission of Sound through the Atmosphere," by Mr. F. J. W. Whipple; "Meteorological Effects on Sea-Level and Tides," by Dr. A. T. Doodson; "The Production of Triatomic Hydrogen," by Mr. G. Stead and Miss B. Trevelyan; "Matter and Radiation," by Sir Oliver J. Lodge; "Apocoptic Expansions," by Mr. T. Smith; "Notes on the Approximate Expression of Empirical Results," by Professor H. Levy and Mr. H. W. Moore; "Series of Magnetic Disturbances," by the Rev. A. L. Cortie, S.J. Demonstrations of "Some Effects of Alternating Magnetism," by Mr. W. M. Mordey, and of "The Frenophone," by Mr. S. G. Brown, are planned for the afternoon.

On Monday, September 17, Professor J. C. McLennan will deliver his presidential address on "The Origin of Spectra." Papers will follow by Professor N. Bohr on "The Correspondence Principle"; by Professor P. Ehrenfest on "Quantisation"; by Professor P. Langevin on "The Structure of Atoms and their Magnetic Properties"; and by Professor R. W. Wood and Dr. A. Ellett on "The Effect of Weak Magnetic Fields on the Polarisation of Resonance Radiation."

On Tuesday a discussion on "The Spectra of the Lighter Elements" is to be opened by Professor J. C. McLennan and to be continued by Professors Bohr, Millikan and Fowler. At noon Mr. R. W. Roberts is to read a paper on "The Magnetic Rotary Dispersion in certain Paramagnetic Liquids," to be followed by a paper on "The Angle of Contact: Variation with relative Motion of Solid and Liquid," by Mr. R. Ablett. Committee reports will be presented.

Section B, Chemistry, will take part on Thursday, the 13th, in the discussion on "Cohesion and Molecular Forces," but will, at 12.30, listen to a paper by Professor Sven Odén on "The Formation of Precipitates," and afterwards to Professor G. S. Whitby on "The Nature and Significance of the Resin of Hevea Rubber."

On Friday Professor F. G. Donnan will deliver his presidential address on "The Physical Chemistry of Interfaces," and general theoretical papers will follow, on "The Quantum Theory in Chemistry," by Professor G. N. Lewis; on "The Bohr Atom and the Periodic Law," by Dr. N. V. Sidgwick; and on "High-Frequency Spectra and the Theory of Atomic Structure," by Dr. D. Coster. Miss Usherwood is to give a paper on "The Activation of Hydrogen in Organic Compounds." In the afternnoon there will be a joint discussion with Section I, Physiology, on "The Physical Chemistry of Membranes in relation to Physiological Science."

On Monday papers are to be presented by Dr. E. F. Armstrong on "Enzymes"; by Dr. K. G. Falk on "The Relation of certain Enzymes to Tissue Differentiation and Tumour Growth"; by Mr. W. G. Palmer on "Catalytic Action in the Presence of Copper"; by Professor W. Vernadsky on "Alumino-Silicates"; and Dr. G. Hevesy on "The Chemistry of Hafnium."

Various papers are to be read on Tuesday. Senatore Ginori Conti will speak on "The Utilisation of Volcanic Steam"; Miss E. S. Semmens on the "Biochemical Effects of Polarised Light"; Dr. R. G. Fargher on "Cotton Wax"; Dr. D. A. Clibbens on "The Absorption of Methylene Blue by Cotton," and Professor H. E. Fierz on "The Sulphonation and Nitration of Naphthalene." A visit to the works of Messrs. Joseph Crosfield and Sons is to be paid in the afternoon.

SUGGESTED METHODS OF TENSION TESTING OF METALLIC MATERIALS.*

I. *Test Specimens.*—In recommending the following specimens for use in tension tests it is not intended to exclude entirely the use of other test specimens for special materials or for special forms of material; for example, in tests of tubing and pipe the form of specimen recommended for plate material (Fig. 1) is not suitable for use, and a special form of specimen is specified. It is, however, recommended that wherever it is feasible the specimens here recommended be used.

Tension test specimens of wire are of the full-size diameter as drawn, and tension test specimens of rods of ductile metal are often of the full-size diameter as rolled. Tension test specimens of pipe and of tubing are frequently of full size as manufactured, in which case the ends should be plugged with metal plugs which shall not extend within the gauge marks. The tension test specimen shown in Fig. 1 is recommended for plate material. The thickness of the specimen is that of the plate material tested. A test specimen with a gauge length of 8 in. is recommended for general use in testing plate material.

Note.—When it is desired to use a specimen with a gauge length of less than 8 in., the numerical dimensions of Fig. 1 should be followed. Specimens with a gauge length of 2 in. are occasionally used.

For thick plate material, it is usually preferable to use a machined specimen rather than to use a specimen the full thickness of the plate.

The tension test specimen shown in Fig. 2 is recommended for general use in testing metals. The gauge length for measuring elongation after fracture is 2 in.

When it is necessary to cut specimens from material (other than plate material) which is of such size that the specimen shown in Fig. 2 cannot be used, it is recommended that a specimen with dimensions proportional to those shown in Fig. 2 be used and that the specimen be made as large as feasible. In any such small-size specimen it is especially important that the gauge length for measuring elongation be four times the diameter of the specimen.

In all tension tests of metals the actual dimensions of cross-section of the test specimens should be measured with a micrometer reading to $\frac{1}{100}$ of the dimension measured, and the stresses should be computed on the basis of the measured cross-section; it should never be assumed that the dimensions of the measured cross-section are identical with the nominal dimensions.

Note.—It will be noted that the tolerance for diameter of specimens shown in Fig. 2 permits the use of specimens 0·505 in. in diameter.

The shape of the ends of the specimen shown in Fig. 2 are not specified above. For specimens of brittle metal it is especially important that the diameter of the specimen be changed gradually along its length from the minimum section at the gauge length to the diameter at the ends. Fig. 3 shows two forms of end of specimen which have given satisfactory results for tests of brittle metals.†

Specimens should be finished so that the surfaces are smooth and free from nicks and tool marks. All wire edges should be removed.

II. *Gripping Devices for Tension Test Specimens.*—For long bars of ductile metal and for the flat plate test specimen shown in Fig. 1, wedge grips, bearing directly on the end of the test specimen, generally furnish a satisfactory means of gripping the specimens. For short specimens and for specimens of brittle material, wedge grips are not a satisfactory means of holding test specimens; it is necessary to use machined specimens and to use special means for insuring that the specimen, when under load, shall be as nearly as possible in pure axial tension. Fig. 4 shows a device for gripping tension specimens with threaded ends, and Fig. 5 shows a device for gripping specimens with shouldered ends. Both these gripping devices are attached to the heads of the testing machine through spherical-seated bearings. The distance between spherical bearings should be as great as is feasible. For brittle materials, even the spherical-seated bearings shown in Figs. 4 and 5 are not always effective in avoiding bending stress on the specimen. The gripping device shown in Fig. 6 has proved satisfactory for testing such specimens, and is an excellent gripping device for any machined test specimen.‡

For specimens cut from thin plate material, ordinary wedge grips are liable to cut the specimens near the edges, giving a tearing stress rather than an axial tension. The self-adjusting grips shown in Fig. 7 have proved satisfactory for tests of thin sheet copper and aluminium.§

For tests of specimens of wire, ordinary wedge grips are liable to cut the wire at the edges of the grips. This cutting has been found to be largely eliminated by the use of grips of the form shown in Fig. 8.‖

In making tension tests, care should be taken to see that the axis of the test specimen is located in the centre line of the heads of the testing machine and that the liners used behind wedge grips are of proper thickness.

* Abstract from a report by the Committee E-1 on Methods of Testing presented at the meeting of the American Society for Testing Materials, at Atlantic City, June 25–29, 1923.

† Specimens similar to those shown in Fig. 3 have been in extensive use in the laboratories of the British Aircraft Service.

‡ The gripping device shown in Fig. 6 has been extensively used in the laboratories of the British Aircraft Services.

§ The grips shown in Fig. 7 have been extensively used in the laboratories of the Aluminum Company of America.

‖ The grips shown in Fig. 8 have been in extensive use in the Materials Testing Laboratory of the Massachusetts Institute of Technology.

From time to time the openings in the heads of the testing machine should be lined up and the heads tested for parallelism. Deviations from correct alignment and from parallelism should not exceed 0·01 in. The movable head of the machine should be free from sidewise motion which is visible to the unaided eye as the machine is run at its fastest speed.

III. *Speed of Operation of Testing Machine.*—The pulling speed has a marked influence on the tensile properties shown by materials tested, an increase in speed increasing the values found for yield point and tensile strength. In testing steel and wrought iron in gauge lengths of 2 and 8 in., the speed of the cross-head when the machine is running idle, shall conform to the following requirements:—

The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but in no case shall the values given in the annexed table be exceeded.

In determining the elastic limit (so-called) by the method prescribed in the American Society for Testing Materials Specifications for Forgings and Cold-rolled Axles (Serial Designations: A 18, A 19, A 63 and A 22), the cross-head speed for the 2-in. gauge length shall not exceed 0·125 in. per min.*

In determining the proportional limit, the cross-head speed shall not exceed 0·025 in. per inch of gauge length per minute.

IV. *The Measurement, after Fracture, of the Elongation and the Reduction of Cross-Section of Tension Test Specimens.*—The measurement of the elongation after fracture of tension test specimens can be made with sufficient accuracy by means of a pair of dividers and a scale. The elongation should not be reported for any tension test specimen which brakes outside the middle third of the gauge length.

NOTE.—If only a few specimens are furnished for testing it is recommended that in marking the gauge length for measuring elongation after fracture it be divided into eight parts, and that if a specimen breaks inside the gauge length but outside the middle third of the gauge length, the requirement in the foregoing paragraph be waived, and the elongation be measured and reported as follows*:—

(1) If the specimen breaks in the middle half of the gauge length (between *C* and *G*, Figs. 9 (*a*) and (*b*)) the

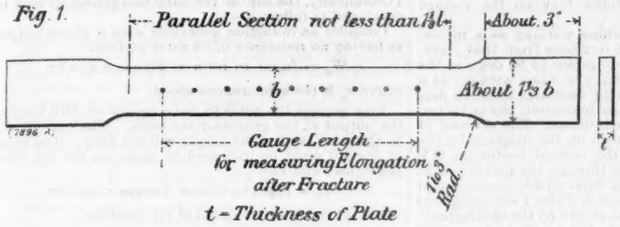


Fig. 1.

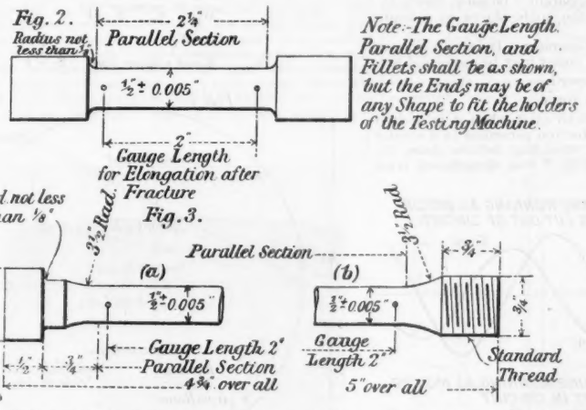


Fig. 2. Fig. 3.

(a) Specimen with shouldered ends. (b) Specimen with Threaded Ends

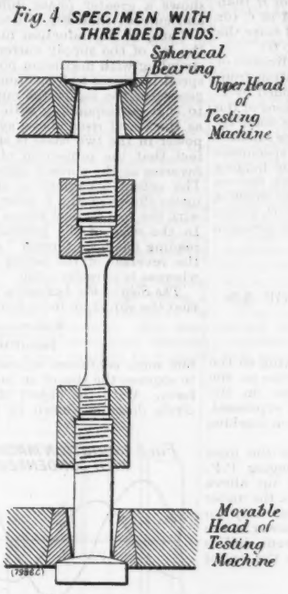


Fig. 4. SPECIMEN WITH THREADED ENDS.

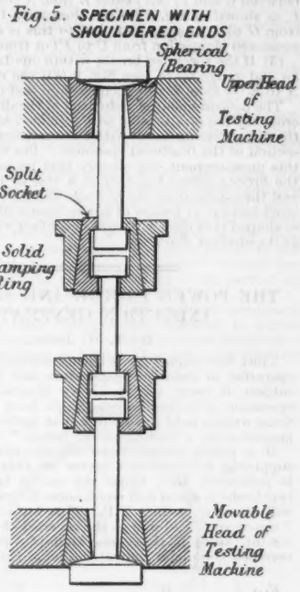


Fig. 5. SPECIMEN WITH SHOULDERED ENDS

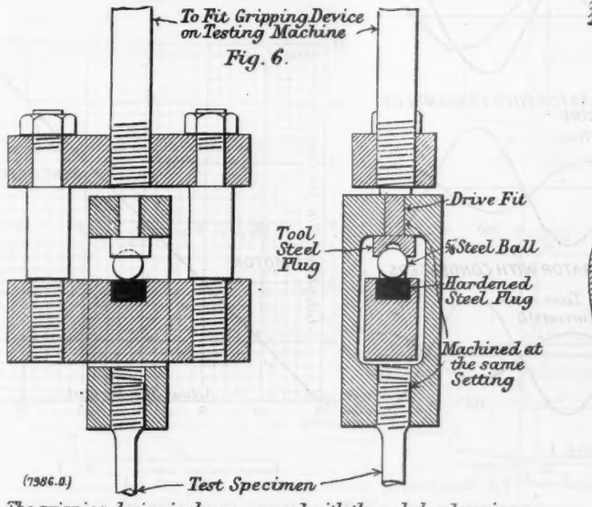


Fig. 6.

The gripping device is shown as used with threaded end specimen. A similar device fitted with split sockets would be used with shouldered specimens.

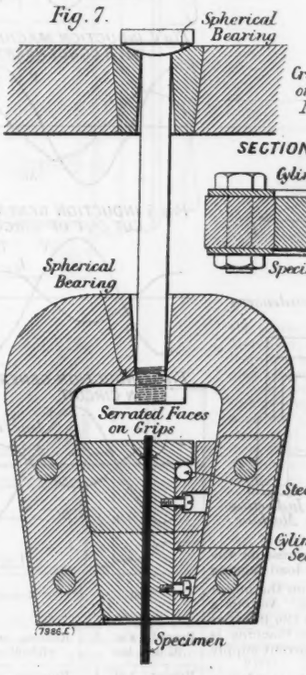


Fig. 7.

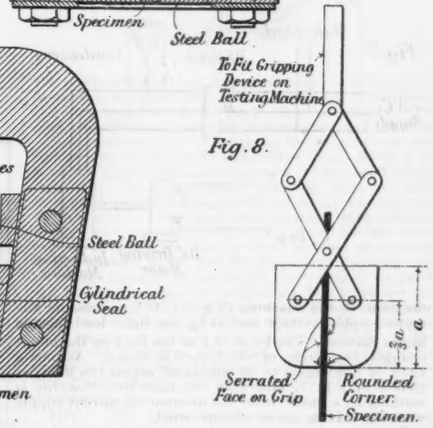


Fig. 8.

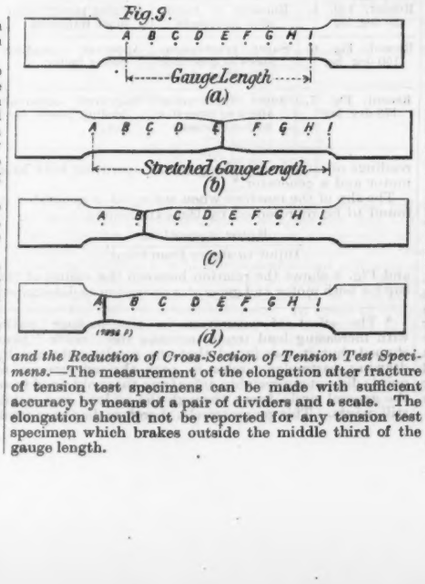


Fig. 9.

Specified Minimum Tensile Strength of Material, lb. per sq. in.	Gauge Length, in.	Maximum Cross-head Speed, in. per minute	
		Yield Point.	Tensile Strength
80,000 or under	2	0·50	2·0
	8	2·00	6·0
Over 80,000	2	0·25	1·0
	8	0·50	2·0

* This method is essentially the same as Method II for the determination of Elastic Limit appearing under the definition for "Elastic Limit" in the Tentative Definitions of Terms Relating to Methods of Testing (E—- 23 T) of the American Society for Testing Materials, p. 23.

* This method is based on suggestions from H. E. Smith, Engineer of Tests of the New York Central Lines, and from R. S. Johnston, U.S. Bureau of Standards.

elongation is measured directly over the stretched gauge length (Fig. 9 (*b*)).

(2) If the specimen breaks between *A* and *C* (or between *G* and *I*) but nearer *B* than *A* (or nearer *H* than *I*, as shown in Fig. 9 (*c*) the elongation from *A* to *C* (or from *G* to *I*) is measured, and to this is added *twice* the measured elongation from *C* to *F* (or from *D* to *G*).

(3) If the specimen breaks within one-half a division of an end gauge mark (see Fig. 9 (*d*)) the elongation from *A* to *E* (or from *E* to *I*) is measured and multiplied by 2.

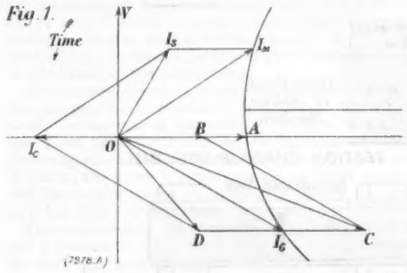
The measurement of reduction of the dimensions of the cross-section of a tension test specimen may be made by the direct measurement with a micrometer of the smallest section of the fractured specimen. For round specimens this measurement can usually best be made by holding the broken pieces together in a vise or between centres and then measuring the average diameter of the smallest cross-section by means of a micrometer fitted with points so shaped that they will come in contact with the specimen at its smallest diameter.

THE POWER FACTOR AND SLIP OF AN INDUCTION GENERATOR.

By T. W. Dann.

Very few papers have been published relating to the operation of induction generators, and literature on the subject is very scanty. Very diverse views on the operation of induction generators have been expressed. Some writers hold the opinion that the induction machine generates at a leading power factor.*

If a power factor meter be connected in the lines supplying an induction motor so that a lagging P.F. is indicated, then when the motor is run up above synchronous speed and commences to generate, the meter will show a leading P.F. This is, however, only an "apparent" lead due to the reversal of the power in the circuit, since if the connection of the current coil is reversed the meter indicates a lag. Consider the vector



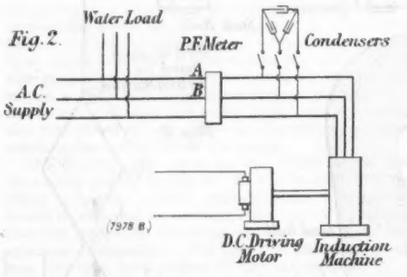


diagram of the machine (Fig. 1), O V represents the motor supply voltage and O I_m the light load lagging motor current. The locus of I as the load on the motor changes, is a circle, of which part is shown. Assume a bank of condensers to be connected across the lines, as shown in Fig. 2, and that the induction machine is working as a motor from the alternating-current supply with the driving motor disconnected.

Under these conditions, O I_c represents the condenser current which leads on O V by 90 deg., whilst O I_s represents the supply current which clearly has a higher power factor than O I_m. This is shown by oscillograph records†, Figs. 3 and 4.

If now the machine is driven by means of the driving motor (see Fig. 2), then as the speed of the motor increases, I travels down the circle through the position O A to O I_g, which corresponds with a generator current and the power in the line circuit is reversed. This is shown by Fig. 5.

O I_g lags behind O V and the condenser current, which leads by 90 deg., is represented as in the motor case by O I_c and the resultant line current O D is more out of phase with O V than is the current O I_g. (See Fig. 1.) This is clearly shown by the oscillograph record, Fig. 6, which shows a greater phase difference between the voltage and current than Fig. 5 does.

Thus, in an induction machine working as a motor, the lag of the supply current increases from that corresponding with maximum power factor to 90 deg., as the speed increases to synchronism, and when working as a generator the lag of the current decreases from 90 deg. to that corresponding with the maximum power factor, as the speed rises above synchronism. The reversal of power in the two cases is shown on the diagram by the fact that the projection of the current vector on O V reverses as the current passes through the position O A. The actual behaviour of the three-phase power factor meter shown in Fig. 2, is set out in Table I and compared with the real state of affairs as shown by the oscillograph. In the case of the generator, the power-factor meter reading has been termed "apparent" because, owing to the reversal of the power the angle shows as a lead, whereas it is really a lag.

The Slip of the Induction Generator.—It is well known that the slip of an induction motor may be expressed as:

$$\frac{\text{Rotor copper loss}}{\text{Input to rotor}},$$

but some confusion appears to exist when it is desired to express the slip of an induction generator in a similar form. With the object of obtaining definite data, the circle diagram shown in Fig. 7 was determined from

Fig. 3. INDUCTION MACHINE RUNNING AS MOTOR WITH CONDENSERS CUT OUT OF CIRCUIT.

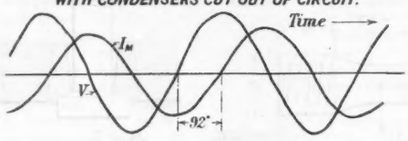


Fig. 4. INDUCTION MACHINE RUNNING AS MOTOR WITH CONDENSERS IN CIRCUIT.

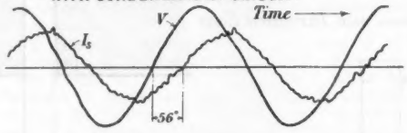


Fig. 5. INDUCTION GENERATOR WITH CONDENSERS CUT OUT OF CIRCUIT.

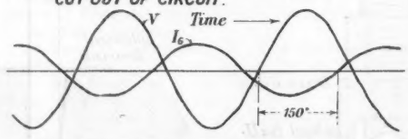


Fig. 6. INDUCTION GENERATOR WITH CONDENSERS IN CIRCUIT.

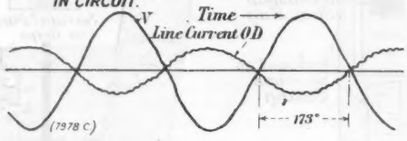


Table I.

Test.	Remarks.	P.F. Meter Reading.
Record, Fig. 3, 92 deg. lag	Running as motor without condensers	Low lagging power factor.
Record, Fig. 4, 56 deg. lag	Running as motor with condensers	Lagging power factor much improved
Record, Fig. 6, 150 deg. lag	Super synchronous speed as generator without condensers	Apparent leading power factor
Record, Fig. 7, 173 deg. lag	Super synchronous speed as generator with condensers	Improved apparent leading power factor.

readings obtained with the machine operating both as a motor and a generator.*

The slip of the machine when acting as a generator is found to be represented by the expression:

$$\frac{\text{Rotor copper loss}}{\text{Input to stator from rotor}},$$

and Fig. 8 shows the relation between the values of the slip for both motor and generator operation as determined from the actual speed and the values of the slip calculated from the above expressions. The agreement is seen to be quite good for both motor and generator operation. Theoretically, the slip of the induction generator may be developed as follows:—

Consider an induction generator with a given output as having no resistance in its rotor and let,

$$W_o = \text{Input to rotor} \propto \text{Torque} \times n_s \times 2\pi$$

where n_s is the synchronous speed.

Now assume the rotor to have resistance, still keeping the output of the generator the same. The current will be the same, and so the torque will not alter. The speed of the set must be increased to make up for the rotor resistance, and now

$$W_r = \text{Input to rotor} \propto \text{Torque} \times n_r \times 2\pi$$

where n_r is the actual speed of the machine.

$$\frac{W_o}{W_r} \times \frac{n_s}{n_r} = \frac{1}{S+1}$$

$$\therefore \frac{W_o}{W_o + \text{Rotor copper loss}} = \frac{1}{S+1}$$

Fig. 7.

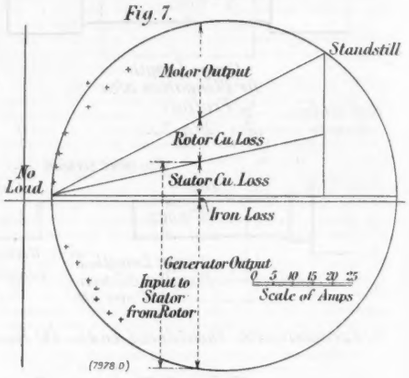
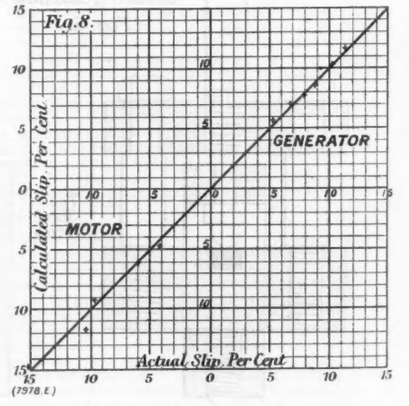


Fig. 8.



$$\frac{1}{\frac{\text{Rotor copper loss}}{W_o} + 1} = \frac{1}{S+1}$$

Hence

$$S = \frac{\text{Rotor copper loss}}{W_o}$$

But since the rotor has no resistance, W_o is also equal to the input to the stator

$$\therefore S = \frac{\text{Rotor copper loss}}{\text{Input to stator from rotor}}$$

A National Gas Exhibition.—Under the patronage of H.M. the King a National Gas Exhibition, demonstrating the Service of Gas in the Home and Industry, will be opened at the Bingley Hall, Birmingham, on Monday, September 17, and will continue until Wednesday, October 3.

Subsidies for Gold Miners.—We learn from *Mining and Metallurgy* that the glut of gold in America has produced such a depression in the gold mining industry that a demand is being made for subsidies to the working mines in order to maintain the wages at an uneconomic rate. The scheme stands, of course, no chance of being adopted, but it is always interesting to note how human nature, taken in the lump, remains the same irrespective of nationality and clime. It is not long since a similar claim was made by the Welsh pitmen, who profiteered so considerably during the war.

* *Electrical Review*, vol. xcii, No. 2354, page 10. C. G. Lamb, "Alternating Currents."

† In all the oscillograph records the current was that flowing in line A, Fig. 2, and the voltage that between the lines A and B. It must also be remembered that in a three-phase system working on unity power factor (a water load for instance) an oscillograph record of the current and voltage taken under the conditions just described, will show a phase difference of 30 deg., and this must be allowed for when estimating the power factor from the oscillograph records with the vector diagram, Fig. 1.

* The effect of saturation in the leakage paths with increasing load tends to make the "circle" pear shaped, but it was found that the results obtained by drawing particular circles to pass through groups of points did not appreciably differ from those obtained from the general circle drawn through the no-load and standstill points. This general circle, therefore, has been used.

ELECTRIC HEATING OF FINISHING ROLLS OF SHEET AND TIN MILLS.*

By GORDON FOX.

THE finishing rolls of practically all sheet and tin mills are made of cast iron. In order that the working surface of the rolls may have sufficient wearing qualities this portion of the roll is cast in an iron mould which causes the molten metal adjacent thereto to solidify quickly. The carbon in this rapidly cooled iron remains in its combined state. The chilled portion of the roll has a white crystalline structure. It is very hard and brittle. The clear chill ordinarily has a depth of about ½ in. to 1 in. The chill tapers off gradually. The entire centre portion of the rolls, including the necks and wobblers, is grey iron which has been cooled sufficiently slowly to permit the carbon to assume graphite form.

This composite structure of the rolls is primarily responsible for the troubles due to roll breakage. The chilled outer portion of the roll has an expansion rate about twice as great as the inner grey iron portion. Thus dimension "A," Fig. 1, tends to expand twice as rapidly as dimension "B." This may cause shearing stress along some such line as C, compression along the line A and tension along the line B. Similar forces occur in an axial direction. Also, due to the more rapid

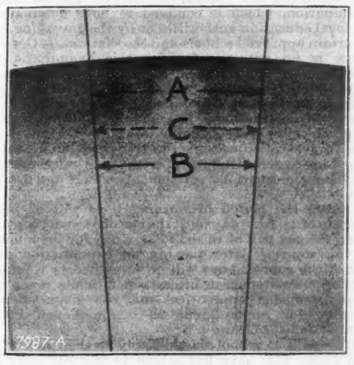
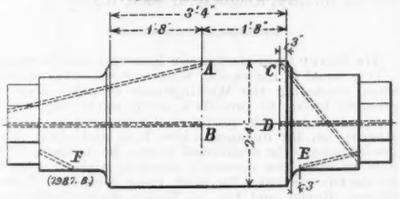


FIG. 1.

Fig. 2. PYROMETER ARRANGEMENT FOR ROLL TEMPERATURES



expansion, the chilled portion tends to pull away from the central portion of the roll, setting up radial tension forces. These conditions would exist even if the roll were uniformly heated. They are decidedly aggravated by the fact that the rolls are heated from the outside and the external portions are permitted to reach fairly high temperatures before the interior is perceptibly heated. The combination of materials having different rates of expansion, heated at different rates and to different degrees, particularly in view of the hard and brittle nature of the chilled metal which is subjected to stress, renders care in the treatment of rolls highly desirable.

The finishing rolls of a sheet mill or tin mill are operated dry and hot. The cooling of the pack is thus minimised. As the hot pack is in contact with the central portion of the rolls the heat enters the rolls at this point. The ends and necks of the rolls are naturally cooler than the centre as their heat is dissipated through contact with the bearings and otherwise. Moreover, in order to maintain proper lubrication of the roll necks and prevent burning of the grease, water cooling of the roll ends is ordinarily employed.

In order to obtain sheets having uniform gauge across their width it is necessary that uniform pressure be maintained across the pack as it passes between the rolls. This means that the contour of the upper and lower rolls must be parallel. Due to the fact that the temperature of the centre of the rolls is higher than the ends, the rolls expand more in the centre, increasing their diameter. In order to compensate for this effect one or both rolls are turned to have a slight concavity of contour when cold. This is termed "crossing" the rolls, for the reason that, in turning, the straight roll (or sometimes a straight edge) is placed above the roll to be given concavity. The straight roll is crossed slightly and the roll being turned is fitted to this crossed roll,

* Paper read before the Association of Iron and Steel Electrical Engineers at Chicago, April 11, 1923.

resulting in a concave contour. When the rolls attain working temperature, the expansion causes the straight roll to become slightly convex, and the concave roll decreases its concavity to such an extent that uniform gauges are obtained. If a mill has too much concavity it is said to be "hollow" and the pack has horns or fish tails. If the mill is "full" in the middle, the pack is longer in the middle than on the sides and the sheets are thinner in the centre than on the edges.

Finishing mill rolls are usually operated at temperatures between 550 deg. and 750 deg. F. at the hottest point. Tests made by the Steel Corporation a few years ago proved that the chilled portion of the roll has the greatest resistance to breakage stresses at about 750 deg. F. The strength diminishes only slightly at lower temperatures down to 350 deg. F. below which point a material weakening was found. At temperatures above 750 deg. F. the strength was found to diminish until, at a temperature of 875 deg. to 900 deg. F., which is a low red heat for cast iron, breakage occurred readily under comparatively light stress.

The distribution of heat in the rolls under normal operating conditions is shown in Fig. 2 and Table I. These temperatures were obtained in a test made at the Vandergrift plant of the Steel Corporation. The temperatures were obtained by thermo-couples inserted in the top roll, collector rings being supplied to connect

Fig. 3.

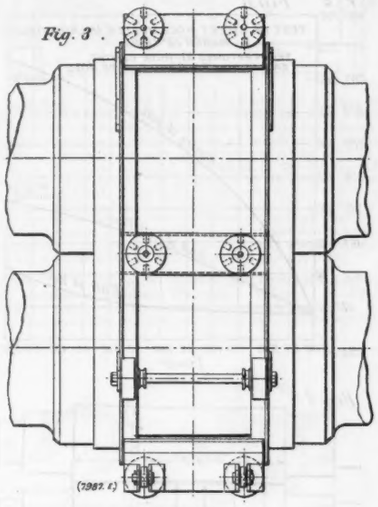
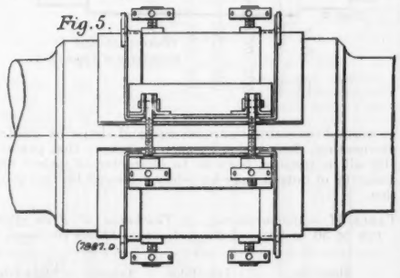


Fig. 5.



with the meter. The mill was rolling light gauge sheets and care was taken not to exceed safe temperatures. These temperatures are probably quite representative of good practice. It should be noted that the surface temperatures at points A and C indicate about 200 deg. F. difference.

TABLE I.—*Temperatures at Points Indicated in Fig. 2, during Normal Operation.*

Point	A—703 to 736 deg. F.
,,	B—641 to 674 deg. F.
,,	C—510 to 542 deg. F.
,,	D—378 to 483 deg. F.
,,	E—399 to 447 deg. F.
,,	F—330 to 366 deg. F.

Due to the fact that rolls are stronger and less brittle at normal rolling temperatures and, further, due to the fact that the rolls have their proper shape only when heated, and also to minimise expansion and contraction stresses, it is highly desirable that roll temperatures be maintained as uniform as possible at the best operating point. On fast schedules it is possible to bring the rolls to a dull red heat. In order to restrict roll temperatures to safe limits, it is customary to cool the rolls, either with dry steam or with air.

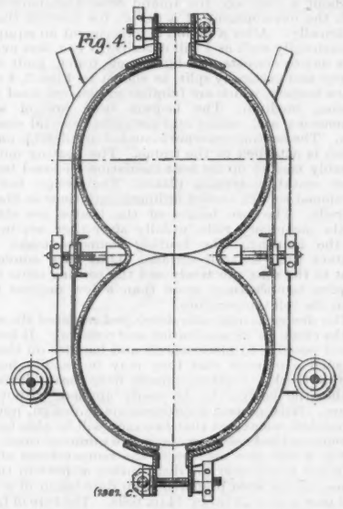
In starting a cold mill, a number of difficulties are met, as follows:—Due to the fact that the rolls must be raised from a uniform low temperature to a non-uniform high temperature, expansion stresses are inevitable. As the mill is "hollow" until full temperature is attained it is not in best condition to roll wide orders and narrow gauges. It is customary to restrict the orders rolled during the warming up turn or turns to narrower widths and heavier gauges. Depending upon the demand and the market conditions this may be of considerable disadvantage from a production and sales standpoint.

Due to the fact that the too rapid heating of rolls is undesirable, being contributory to excessive roll breakage, it is the practice in many mills to restrict the output on the first turn or turns. If this practice is not followed there is always the probability that roll life is being sacrificed. On the other hand, restricted output naturally represents a loss. It is largely a matter of choice between two evils.

The rolling of narrow iron on the first turns concentrates the wear on the mill to some extent and probably decreases the total usage on wide iron which might be obtained from a set of rolls. Aside from the necessity of warming up the mill, it would seem to be the more desirable practice to roll wide iron during the early part of the week while the surface of the rolls is in best condition and to roll the narrow iron the latter part of the week after the rolls are worn.

The lubricant used for the roll necks is necessarily suited to the high temperatures incident to normal operation. When a mill is started cold the lubricant is stiff and the friction is high. This not only increases

Fig. 4.



the power required but it sometimes leads to breakages. Moreover, since the upper roll is usually driven by friction from the lower roll or the pack, slippage is likely. This may contribute to gathering and roughness of the rolls.

It is probably the practice in the majority of mills to warm up on crop ends and narrow iron. Some of the possible disadvantages of this practice have been already intimated. It is probable, however, that a rather intangible question, that of roll breakage, is an important consideration. Very high temperatures, intermittently applied at the central portion of the roll surface surely cannot be considered as an ideal method of warming up. Just how much roll breakage may be attributed to strains brought about during the warming up period can hardly be definitely ascertained, but when we consider that a cold roll, in a sensitive condition, is subjected to its most severe stresses at this time, there is very good reason to believe that no little damage is done during the warming up period. In an article which appeared in the May, 1922, issue of "*Blast Furnace and Steel Plant*," Mr. W. H. Melaney makes the following statements:—

First: The chilled surface of the roll as previously stated has an expansion approximately twice that of the grey granulated interior.

Second: Under all the present-day processes of warming up, this chilled surface of the roll is the first part to be heated, thus accentuating an already precarious condition, as the chilled surface must of necessity become quite hot before the grey metal behind it is even warm. This is conclusively shown when rolls sometimes break before a half dozen bars have been rolled on them, and when the heat in the roll is not sufficient even to discolour the fracture; and in deep chilled rolls many are broken simply by the warming up and before even a bar has been rolled on them.

Third: Many seemingly perfect rolls are broken during the warming up process when there is no pack in the mill. This is caused by the surface of the roll becoming heated so rapidly that the interior of the roll did not get warm enough to expand the slight amount its prepondering mass would require, to take care of the very rapid expansion of the face or chilled portion, and the roll is torn in two.

Fourth: It is a known fact that most of the roll breakage occurs in the fore part of the week before the rolls have reached their final working temperature; also there is more breakage in the extremely cold winter months than in the summer time, due to the lower temperature at which the warming up starts, and it is the writer's opinion that no matter when the roll actually

lets go, the condition that finally puts it out of commission was started on the warming up turn.

The importance of the question of roll breakage is evidenced by the records of one mill which show that only 15 per cent. of the rolls are discarded due to the fact that they have been dressed down below the chill. The other 85 per cent. are lost through breakage. Some of the rolls serve over 100 days, some serve less than 10 days. The average for this mill is about 47 days.

A 28 in. by 44 in. roll weighs about 6 tons and costs about 70 dols. per ton or 420.00 dols. The scrap value is about 15 dols. per ton or 90.00 dols. Whatever labour is put on the roll is lost when it breaks. If a roll breaks when it has served but half its useful life, the loss is on the order of 150.00 dols. or more. If roll breakage can be decreased, the possibility for saving is worth while.

Rolls which have a deep chill are more sensitive and more subject to breakage than those having a shallow chill. Thus new rolls are more sensitive in this respect than old rolls which have been repeatedly dressed.

In the foregoing we have mentioned some of the considerations which render it desirable that rolls be carefully pre-heated before rolling. A number of methods have been tried and some are now in use. Hot water and steam are both used to some extent and gas burners are applied to the rolls in some mills. Hot gases from the heating furnaces have been blown on the rolls in some cases. All of these methods have limitations.

About a year ago the Inland Steel Company undertook the development of a device for heating the rolls electrically. After a period of experiment an equipment substantially such as I will describe to you, was evolved. This device consists of a light angle frame, built in two halves and vertically split, as shown in Figs. 3, 4 and 5. Space heaters, which are familiar to you, are used as the heating medium. The heaters used are of special dimensions and rating and somewhat special construction. The heating units are mounted in a flexible member which is attached to the frame. The heating units are suitably backed up by heat insulation enclosed between sheet metal protecting plates. The design has been developed to take care of ordinary variations in diameter of rolls. The two halves of the heater are clamped to the stationary rolls, usually after they are in place in the housing. The heating elements make direct contact with the roll surface. Thus they convey the heat to the rolls effectively and the heating units do not acquire temperatures more than a few degrees higher than the roll temperature.

The device as originally developed required the service of the crane for its application and removal. It has been found possible to place wheels and handles on the units in such a manner that they may be readily handled, like a truck. Further, means have been devised to enable the heaters to be easily applied without the crane. With certain improvements in design, now contemplated, we expect that two men will be able to apply or remove the heaters in about five minutes' time.

Fig. 6 will give an idea of the temperatures afforded with the heater and the distribution of heat in the roll. These curves were prepared from data taken in a recent test on a pair of 28 in. by 44 in. rolls. The rate of heating indicated was obtained by continuous application of about 28 kw. of energy for a period of six hours. The total power consumption of about 170 kw. hours represents a cost of about 2.00 dols. for the heating period. It will be noted that a maximum temperature of 424 deg. F. was obtained at the centre of the roll face and 226 deg. F. at the end of the roll face after six hours' heating. This represents a temperature difference of 198 deg. F. which corresponds closely with the temperature difference between these points existing when the rolls are in normal operation.

The results shown in this test do not necessarily represent the best that can be secured. First, it may be definitely stated that temperatures higher than 424 deg. F. may be attained, if desired, either by longer or more rapid heating. In the above test the voltage was 15 per cent. low. As the heat produced varies as the square of the voltage, this reduced the heating ability of the equipment 28 per cent. The heating units will stand considerably higher temperatures without damage.

The more rapid the heating, the more the centre of the roll is heated and the less the heat has time to flow to the roll necks and ends. Moreover, with rapid heating, the roll surface is no doubt considerably hotter than the roll interior although probably much less so than with gas flame heating. It is entirely possible to govern the distribution of heat through the roll according to the rate of input to the heater which, of course, may be easily regulated. Much remains to be learned in this regard. It appears probable that it may be best to operate the heaters connected in series at reduced input for an hour or two until the frost is driven out of the rolls and they have attained some temperature fairly well distributed; the heaters can then be connected in parallel and more rapid heating employed to bring the rolls up to suitable working temperatures and to shape.

The heating units in the electric heater do not cover the entire periphery of the rolls. Small arcs at the top and bottom of each roll are not covered. It might perhaps be thought that this would lead to non-uniform heating, leading to stresses and non-uniform expansion. As an actual fact, the rate of heat input is low enough and the rate of heat flow is high enough so that no temperature differences of any moment occur. Repeated tests have failed to show temperature differences greater than 15 deg. F. between different points around the circumference of a roll. The upper side of the roll is usually 5 deg. to 10 deg. F. warmer than the lower side, and differences of 4 deg. to 5 deg. F. are not exceeded over any quarter circle arc.

The effect of electric pre-heating on the shape of the rolls is well shown in Fig. 7, which shows the amount of concavity or cross in the rolls discussed in connection with Fig. 6. It will be noted that, when cold, these rolls had a maximum separation at the centre of 0·025 in. After heating, and when the heaters were removed, the clearance was 0·009 in. Thus about two-thirds of the concavity was removed by pre-heating. This test was made on a pair of rolls which had been dressed to about half the original chill.

The results above shown have been confirmed in several other tests, with the exception that lower final temperatures were then obtained as the heaters used were of lower capacity. In a test run last November, a pair of 28 in. by 44 in. rolls was pre-heated to a temperature of 348 deg. F. at the centre of the face. After running through three or four crop ends to set the mills, some 28 × 30 × 96 orders were run. The first pack had about 12 in. fish tails. A sample strip, cut across the pack, was calipered, the dimensions of each strip and the average of several measurements of the pack being given in Table II. In considering this data, cognizance should be taken of the fact that this mill was found to be hollow the entire week and fish tails of 8 in. to 10 in. resulted on the same order on succeeding turns. Orders of 28 × 36 × 96 have been successfully rolled on the first turn after pre-heating with the electric heater. In view of the fact that the rolls can be brought nearly

Fig. 6.

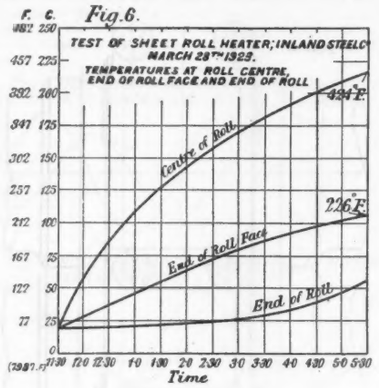
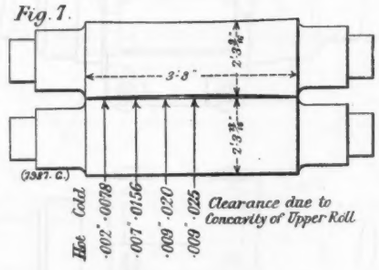

F. C.
TEST OF SHEET ROLL HEATER; INLAND STEEL CO MARCH 28TH 1923.
TEMPERATURES AT ROLL CENTRE, END OF ROLL FACE AND END OF ROLL
424° F.
226° F.
Centre of Roll
End of Roll Face
End of Roll
Time

Fig. 7.



to normal operating temperatures and shape by electric pre-heating, there is good reason to believe that practically all limitations both as to character of orders and quantity of output may be safely removed by this practice.

Table II.—*Measurements of Thickness of First Pack (28 × 30 × 96) and the Individual Sheets in Same.*

Sheet No.	Left Edge.	Centre.	Right Edge.
1	·0111	·0124	·0112
2	·0103	·0144	·0120
3	·0109	·0143	·0120
4	·0105	·0140	·0110
5	·0120	·0147	·0118
6	·0120	·0146	·0113
7	·0136	·0145	·0134
8	·0112	·0128	·0117
Average	·0114	·0140	·0118
Total	·0917	·1117	·0946
Measured thickness of pack	·1081	·1144	·1056

Individual sheets are about ·002 heavier in centre than ends. Pack is about ·008 heavier in centre than ends.

Although the heaters are usually applied to the rolls on Sunday evening for a few hours prior to the first turn it is also possible to apply them to a pair of rolls placed in a suitable stand. Thus, in case it becomes desirable to change rolls during the week, a pre-heated set may be installed and the necessity of a change of orders for warming up may be avoided.

In summarising it may be said that the same advantages which accrue to electric heating in many other operations also occur in this application. The heat may be effectively and economically applied. It may be readily controlled. Any degree of heat desired may be obtained. The method is clean, convenient and economical, and the application and operation can be so governed as to offer considerable possibility for decrease in roll breakage. The method is new and its possibilities are not as yet fully developed. It gives promise of being a thoroughly satisfactory method of pre-heating rolls. The benefit which it may afford is measured largely by the importance or need of a satisfactory pre-heating method. Mill operators are the best judges of this need. The interest shown by the few who know of this development indicates that it will be well received as an improvement in the art.

APPRENTICES FOR THE ROYAL AIR FORCE.

The Government's decision to increase the strength of the Royal Air Force for purposes of home defence has rendered necessary the engagement of considerably increased numbers of aircraft apprentices for training as skilled craftsmen. About 950 boys will be required for entry in January next, and they will be selected on the results of either of two competitive examinations which will be conducted by the Civil Service Commissioners and the Air Ministry, respectively, in conjunction with local education authorities in different parts of the country. Candidates must be physically fit and be between 15 years and 16½ years of age at the time of entry, although in some cases the upper age limit may be extended to 17 years.

The closing date for entries to the Civil Service examination has now passed, but that for the Air Ministry examination, which is confined to boys nominated by the local education authorities or by the governing bodies of certain approved schools and associations, is October 2. There is no entrance fee for this examination, the syllabus for which includes papers on mathematics, experimental science, English and a general paper suitable for boys still at school and following a normal course of instruction. The successful candidates will by given three years' training in a skilled trade, in addition to general education, the trades including those of carpenter-riggers, fitters, coppersmiths, wireless operators, mechanics, electricians, instrument-makers and draughtsmen.

During the period of training boys will be paid at the rate of 1*s.* 6*d.* a day until the age of 18 years is reached, when the pay will be raised to 3*s.* a day for the remainder of the course. After passing an examination at the end of the course, boys will be promoted to the rank of leading aircraftsmen or aircraftsmen, while some of the more promising apprentices may be given additional training for appointment as commissioned or non-commissioned officers.

Boys still at school should apply to their headmasters and those who have left school to the Advisory Committee for Juvenile Employment of the area in which they reside. Boy scouts can apply to the authorities of that organisation and Territorial cadets to their Commanding Officers. Headmasters and others interested in the scheme can obtain copies of the regulations for entry (A.P. 134) on application to the Secretary, The Air Ministry, Kingsway, London, W.C.2.

Air Brake Compressor for Electric Locomotives.—It is usual in the case of electric locomotives on railways employing the Westinghouse or other form of pressure brake, to provide a small electrically driven compressor for this purpose. Under certain circumstances, as, for instance, where long and steep down grades have to be negotiated, it may be desirable to be able to raise the necessary pressure without recourse to electric current. To meet these conditions Messrs. Brown, Boveri and Co., of Baden, Switzerland, have produced a small compressor which is driven from the driving wheels of the locomotive. The compressor is single acting, and has a trunk piston coupled, by means of a connecting rod, to a return crank of small throw fitted to one of the side rod crank pins. The compressor is fixed by a bracket to the main bogie frame of a double bogie electric locomotive having leading and trailing wheels. It is very simple in design, is provided with cooling fins, and a separate head casting containing the suction and delivery valves. It is coupled with the motor driven compressor system and may be used in conjunction with it or independently and is said to have proved very satisfactory in service.

The Engineer in Public Service.—Those American and Canadian cities who have taken "out of politics" the operation of their water supplies and other public services, by placing the direction of these in the hands of engineer commissioners, have uniformly acknowledged that the results have been exceedingly satisfactory. It was not, however, popular with the politicians, who have in many instances finally succeeded in ousting the technical man from his position. Indeed, Mr. Waddell, the well-known bridge engineer, relates one case in which the post of county engineer was filled by a lawyer on the ground that the holder must be a politician. It would appear from a recent example that a similar tendency is showing itself even in the Federal services. Thus it is announced that Mr. Arthur P. Davis, past-president of the American Society of Civil Engineers, who has for 20 years been head of the United States Reclamation Service, has been removed from his position in order that he may be replaced by a non-technical man. Not wholly dissimilar incidents have occurred in connection with our own Government departments, where the clerical element strongly resents the appointment of a man with technical qualifications to an administrative post. Probably if our railways were nationalised we should no longer see engineers appointed to general managerships.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

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ELECTRICAL APPARATUS.

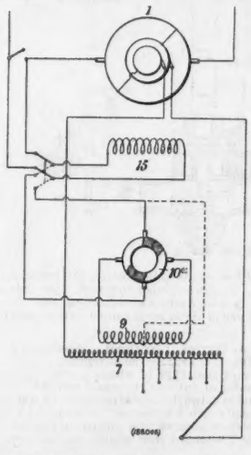
198,137. L. I. Robinson, London, and W. E. Warrilow, London. Insulating Coverings for Wires. (5 *Figs.*) March 24, 1922.—The invention relates to sectional coverings for wires, cables or similar flexible members. According to the invention, the sectional covering comprises a series of balls 2 arranged alternately with bearing members 1 to form a series of ball and socket joints, wherein the bore of the bearing members 1 is large

Fig.1.

Fig.2.

enough to permit free movement of the wire therein when the covered wire 3 is bent or looped until the opposed faces of adjacent bearing members touch, the bore of the intermediate spherical members 2 being large enough to permit bending of the wire within the length of the bore to conform without strain to the maximum general curvature that can be given to the covered cable. (*Accepted June* 6, 1923.)

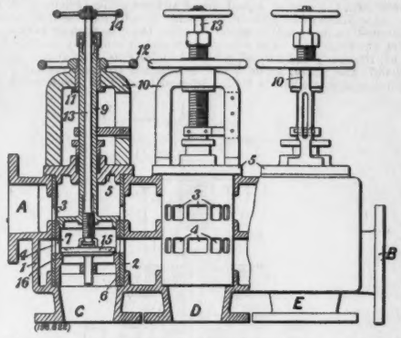
198,046. R. D. Archibald, Broughty Ferry, Dundee. Continuous Current Dynamo Electric Machines. (1 *Fig.*) February 23, 1922.—The invention provides a dynamo electric machine having field windings consisting partly or wholly of coils connected in series with the armature which, amongst other purposes, may be used in a regenerative control system. According to the invention, there is combined with a series or compound-wound dynamo electric machine, a rectifier 10a connected at one



side to the series windings 15 and at the other side to tappings from the armature 1 of the machine or another machine working in conjunction therewith; thus in a tramcar, for example, one rectifier may be employed connected at one side to the series windings of all the machines and at the other to tappings from the armature of one of them. Preferably, a transformer 7, 9 is connected between tappings from the armature of the machine or another machine working in conjunction therewith and the rectifier 10a. (*Sealed.*)

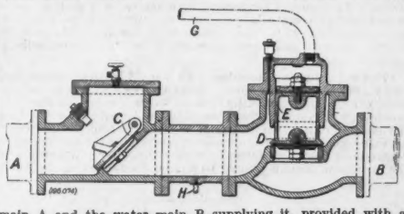
HYDRAULIC MACHINERY.

198,622. K. B. Jacob, Middlesbrough. Multiple Way or Switch Valves. (2 *Figs.*) December 5, 1922.—The invention has relation to valves that control three ducts and, according to the position of an adjustable member, connect a duct with one or other of two ducts. In accordance with the invention, a multiple-way or switch valve comprises a valve casing having three inlets or outlets thereto, a compound valve member mounted in the valve casing and comprising a slotted sleeve movable in the direction of its axis without rotation in relation to two of the inlets or outlets and a disc valve contained within the slotted sleeve to control the slot or slots in the sleeve, and means for operating the members of the compound valve member independently or simultaneously. 1 is the valve casing which has at its upper part a flanged inlet or outlet A, at its lower part a flanged inlet or outlet B, and at its bottom the flanged inlet or outlet C (or D or E). The valve casing 1 has a liner 2 that is provided with a slot 3 opposite A, and with a slot 4 opposite B. The bottom end of the liner is in communication with the inlet or outlet C (or D or E). The liner 2 is closed at its upper end by a cap 5. Within the liner 2, and movable in relation thereto, is a sleeve 6 that is formed with a slot 7 which is so positioned that, when the sleeve 6 is in one position, the slot 7 is coincident with the slot 4 and, in another position, is coincident with the slot 3. The sleeve 6 is open at its lower end to C (or D or E) and is closed at its upper end by a cap. Integral with the cap is a hollow valve spindle 9 that passes through the cap 5 and through a bridge piece 10. The spindle 9 is screwed externally, and mounted so as to rotate within the bridge-piece 10 is a nut 11 which engages the thread



of the spindle 9. The nut 11 carries a hand wheel 12, rotation of which causes the sleeve 6 to rise or fall within the liner 2 and bring the slot 7 into line with the slot 3 or 4. Extending through the spindle 9 is a second valve spindle 13, which carries at its upper end a hand wheel 14, and, at its lower end a disc valve 15. This valve 15 fits on to a seat 16 formed in the interior of the sleeve 6. The spindle 13 is screwed at its lower end, as is also the lower end of the bore of the spindle 9. The two threads just mentioned mesh, and the disc valve 15 is raised or lowered in relation to its seat 16 by rotation of the hand wheel 14. Rotation of the hand wheel 12 raises the sleeve 6 and disc valve 15 simultaneously, and rotation of the hand wheel 14 moves the disc valve 15 in relation to the sleeve 6. (*Accepted June* 13, 1923.)

196,074. N. B. Ellington, Chester, and Hydraulic Engineering Company, Limited, Chester. Valves. (1 *Fig.*) January 13, 1922.—An arrangement for preventing reflux in water mains comprises a water cock fitted between the service



main A and the water main B supplying it, provided with a check valve C at the service end and a control valve D with piston E subject to the pressure existing in the service pipe through a connection G. A drain H may be provided. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

195,720. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-upon-Tyne, H. W. Lee, Newcastle-upon-Tyne, and J. W. Swindale, Newcastle-upon-Tyne. Ammunition Hoists. (6 *Figs.*) December 31, 1921.—The invention relates to means for actuating ammunition hoists in

Fig. 2.

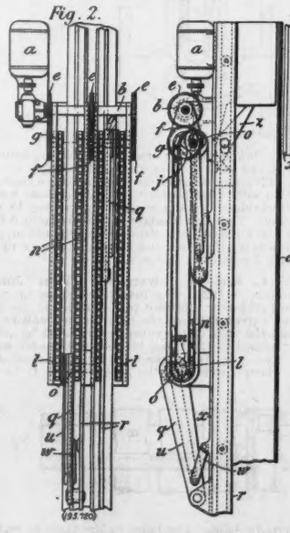
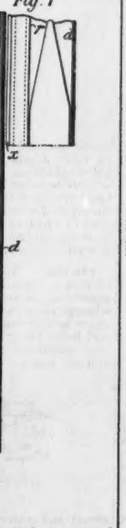


Fig. 1



which the projectile is caused to ascend a trunk by means of lifting arms pivoted to sliders reciprocating in the trunk. An electric motor *a* drives through reduction gearing a shaft *b* mounted on the trunk *d* of the hoist. Upon the shaft *b* are three toothed wheels *e* in mesh with three other toothed wheels *f* on three short shafts *g* mounted in bearings on the trunk *d*. Upon the shafts *g* are also mounted four sprocket wheels *j*. In bearings on the trunk *d* are also mounted three other short shafts *l* upon which are mounted four sprocket wheels *m*. Four chains *n* are mounted on the four pairs of sprocket wheels *j* and *m*. The chains *n* are coupled together in pairs, each pair being coupled to a bar *o* by angle couplings, the couplings being so arranged that when one coupling is passing the sprocket wheels *j* the other coupling is passing the sprocket wheels *m*. The ends of two connecting rods *q* are pivoted on each of the bars *o*, the other ends being pivoted to sliders *r* in the trunk; to each bar *o* is keyed a pair of plates having cam grooves, running in which are rollers on one end of a rod *u* which is slotted to engage the bar *o*. The other ends of the rods *u* can slide in slots in the corresponding connecting rods *q*. The rods *u* are connected by links *w* to other rods *x* on the sliders *r*, in which rods are recesses engaging with teeth on lifting arms *z* pivoted to the sliders *r*. By the movement of the chains *n* one slider *r* is raised whilst the other is lowered, and at the end of the reciprocating movement of the sliders, the arms *z* on the sliders *r* are turned out of the path of the projectile in the trunk *d* by the reciprocating rods *x*. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

198,027. J. G. H. Budd, London. Gear-Cutting Machines. (7 *Figs.*) February 18, 1922.—A work-holding and operating attachment for use with gear-cutting machines according to this invention, comprises broadly, mechanism that can be applied to a gear-cutting machine, after the removal of the ordinary rotary work arbour therefrom, and be driven from the ordinary driving spindle of the machine. The attachment comprises a frame or body *a* adapted to be supported upon the rotary worktable of a gear-cutting machine, an arbour or spindle *f*, which replaces the ordinary work arbour of the machine, and extends through the body *a* and is adapted to be driven by the

Fig.1.

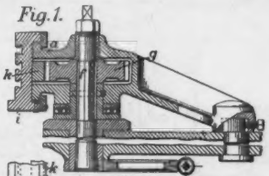
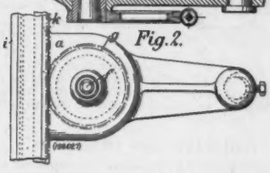


Fig.2.



driving spindle of the machine, a spur wheel *g* driven by the arbour or spindle *f*, and a rack *k* in gear with the spur wheel and carried by a worktable or carrier *i* which is mounted to move in a rectilinear or curvilinear path on correspondingly shaped guides carried by the body, and is adapted to support the work that is to be cut by the movable gear cutter of the machine, for the purpose of forming a straight toothed rack, or a curved toothed segment. The body *a* is provided with means whereby it can be fixed in position, which it may be after suitable adjustment, for the purpose of preventing it rotating relatively to the machine during the action of the cutter on the work. (*Accepted June* 6, 1923.)

196,113. British Timken, Limited, Birmingham, and F. Loader, Birmingham. Roller or Ball Bearings. (3 *Figs.*) January 26, 1922.—In a roller bearing in which the rollers 3 are spaced by a split spring cage 1, the openings 2 for the rollers are closed at the ends, and, after the rollers have been inserted in the

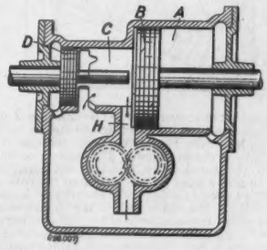
Fig.1.

Fig.2.

cage, the latter is expanded and slipped over the ridge 5 of the inner race into its working position. The cage is suitable for conical or cylindrical roller bearings or ball bearings, and may be stamped from a tube or from a sheet metal blank. (*Sealed.*)

MOTOR ROAD VEHICLES.

198,007. D. Napier and Son, Limited, Acton Vale, London, and G. S. Wilkinson, Acton Vale, London. Brake-Actuating Mechanism. (2 *Figs.*) January 26, 1922.—The invention relates to brake-actuating mechanism of the kind



in which liquid under pressure, controlled by the movement of a valve actuated by the brake lever, is delivered into a cylinder containing a piston connected to the brake-applying mechanism. According to the invention, a piston valve D and the brake-applying piston B are respectively contained within cylinders

C, A, which adjoin at their open ends and the liquid under pressure from a suitable reservoir is delivered into the space between these two pistons through an inlet port H, the escape of this liquid being controlled by means of the piston valve D. Thus when the piston valve D is actuated and the outflow of liquid is restricted or stopped, the hydraulic pressure will act on and cause movement of the piston B, which is connected to the brake mechanism, and the brakes will be applied with a force which will vary in accordance with the extent to which the circulation of the liquid through the cylinders is obstructed. (*Accepted June 6, 1923.*)

197,400. S. E. Alley, Westminster. Motor Road Vehicles. (3 *Figs.*) February 10, 1922.—The invention relates to steam tractors. According to the invention, the driver's seat 3 is located in front of the boiler 2, which is fired from the front, and is arranged between the front and rear wheels substantially over

Fig. 1.

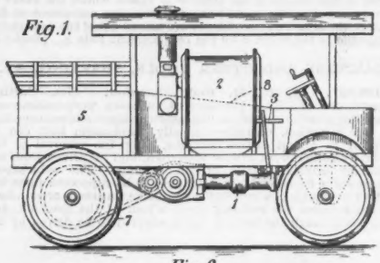
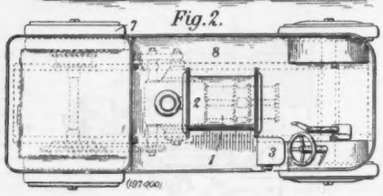


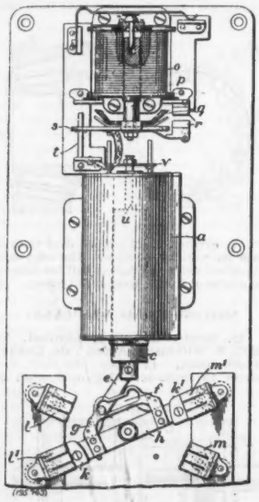
Fig. 2.



the engine 1 and in front of the water tank 5, which is located over the driving wheels 7 and a gangway 8 is provided to one side of the boiler to give the stoker access to the fuel, which, together with the water tank, occupies the whole of the space to the rear of the boiler. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

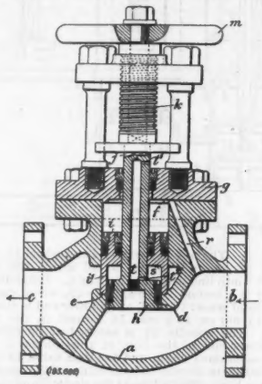
195,763. J. Stone and Co., Limited, Deptford, and C. E. Adams, London. Train Lighting Installations. (4 *Figs.*) January 9, 1922.—The invention comprises improvements in and connected with electromagnetic switches for train lighting installations and is concerned with what are known as double-battery installations. According to the invention, the electromagnetic change-over switch is adapted so that, when operating, it alters the conditions of the electromagnetic cut-in switch and makes it possible for the cut-in switch to operate after the change-over has taken place. The coil *a* of the change-over switch solenoid is mounted vertically and the lower end of the core *c* is forked for the pivotal suspension of a link *e*. The lower end of the link *e* is fitted with an anti-friction roller adapted to move in a slot *f* formed in an arched member *g* secured to a see-saw lever *h*. The ends of the lever *h* are fitted with insulated contact blades *k*, *k*1 adapted to engage between diagonally opposite pairs of spring contacts *l*, *m* and *l*1, *m*1. The spring contacts *l*, *m*, *l*1, *m*1 are



connected up so that the reversal of the lever *h* effects interchange of the battery connections for effecting the change-over. Above and axially in line with the change-over solenoid is mounted the solenoid *o* of a cut-in switch. The core *p* of this solenoid is fitted with the usual main brush *q* and auxiliary carbon contact *r*. An arm *s* fixed to the bottom of the core *p* is forked to engage with a vertical guide pillar *t* electrically connected with the switch brush *q*. The upper end of the change-over solenoid core *c* is fitted with a non-magnetic rod *u*. The upper end of this rod is fitted with a guided crosshead *v*. The core *p* of the cut-in solenoid is arrested in its down position by a stop which is disposed so that there is an appreciable air gap in this position. In operation, the coil *a* of the change-over solenoid being connected across the dynamo comes into operation at a voltage which is less than the cut-in voltage. The core *c* of this solenoid in rising and reversing the change-over switch lever *h*, also causes the rod *u* to strike against the lower end of the core *p* of the cut-in solenoid and to lift the core *p*, thereby reducing the air gap in the cut-in solenoid. As the speed of the train increases the cut-in speed is soon reached giving a dynamo voltage sufficient to cause the cut-in switch solenoid to operate and draw in its core *p* over the reduced air gap. In this way the precedence of operation of the change-over is ensured. (*Sealed.*)

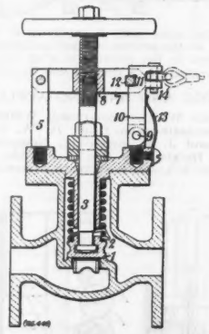
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

195,692 E. A. Mitchell, London, and J. A. E. Buris, Kenton. Stop Valves. (4 *Figs.*) December 6, 1921.—This invention has reference to stop valves. The valve casing *a* has inlet and outlet branches *b*, *c*, respectively, a cylindrical valve seat *d*, a flat annular seat *e*, and a vertical chamber *f* coaxial with the seats *d*, *e*, and closed at the top by a cover *g*. *h* is a piston valve which slides endways in the cylindrical seat *d* and is adapted in its closed position to close the passageway between the branches *b*, *c*. *i* is a protective piston mounted to slide in the chamber *f* and formed with a tubular extension *i*1 that surrounds the piston valve *h* and is adapted to bear against the annular seat *e* when in its lowest position. The piston valve *h*



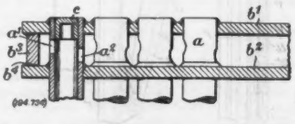
is carried by a spindle *j* that extends through the protective piston *i* and the cover *g* and is moved endways by a screw *k* and hand wheel *m*. The chamber *f* above the protective piston *i* is in permanent communication with the fluid inlet side of the valve casing *a* through a passage *r*, so that when the stop valve is in use, the upper side of the protective piston *i* will be constantly subjected to the pressure of the fluid in the inlet side of the valve casing. The space *s* between the piston valve *h* and the protective piston *i* and its tubular extension *i*1 is in constant communication with the external atmosphere through a central passage *t* and lateral passages *t*2 in the valve spindle *j*. (*Sealed.*)

195,446. James Howden and Co., Limited, Glasgow, and C. W. Hume, Glasgow. Stop Valves. (1 *Fig.*) December 29, 1921.—The invention relates to stop valves of the type provided with a spring 2 surrounding the spindle 3 for effecting the closure of the valve 1, and a latch or trip device which normally holds the valve open in opposition to the spring and is controllable from a distance to release the valve. According to the invention, there is jointed to a pillar 5 arranged on the valve



casing one end of a bridge-piece or crosshead 7 having between its ends a nut 8 engaging a screw-threaded portion of the valve spindle 3. Pivotally mounted at 9 on the valve casing is a strut 10 provided with a latch socket 11 which engages with a latch pin 12 on the bridge-piece and is urged by a spring 13 into the latched position. The strut is adapted to be unlatched by a cord 14 which can be worked from a distance whereby the support from the bridge-piece is withdrawn and the rapid closure of the valve by the spring 2 permitted. (*Sealed.*)

194,734. W. L. Knowles, Liverpool. Tube Joints. (2 *Figs.*) December 19, 1921.—The invention relates to steam generators as used on motor propelled road vehicles of the kind wherein the tubes extend through the inner header wall to the outer header wall, the ends of the tubes being closed by plugs, and holes being formed in the tubes between the header walls. Two perforated plates b_1, b_2 are spaced apart by means of an annular ring b_3, which is welded at the joints b_4 so as to form a



steam and watertight joint. The holes in the plate b_1 register with the holes in the plate b_2. The ends of the tubes *a* are passed through the holes in both plates b_1, b_2, and are welded to the plates in the angles between the tubes and plates so as to form steamtight joints. Transverse holes a_3, a_2 are formed in opposite sides of the tubes *a* and in the end of each tube is placed a plug *c*, which may be bored longitudinally, these plugs when in position being welded to the tubes *a* as shown. (*Sealed.*)

TEXTILE MACHINERY.

194,103. J. P. Hilton, Middleton, and J. Nuttal, Middleton. Travelling Lattices. (3 *Figs.*) February 7, 1922.—The invention relates to the lattices employed in cotton-preparing machinery. The strips or lags A are affixed to lengths of canvas, leather or other material in the ordinary way. A metal plate C^1 is affixed to the first lag A^1, and a second metal plate C^2 to the last lag A^2. The plates C^1, C^2 are preferably arranged in pairs, one pair at each end of the lags A^1 and A^2. Each plate C^1, C^2 is provided with one or more tubular projections c^1, c^2 arranged to project above the lags. The projections c^1 on the

Fig. 1.

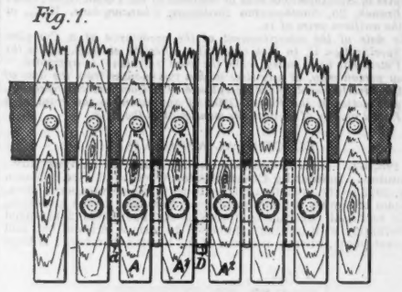


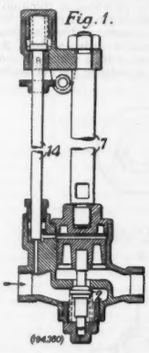
Fig. 2.

plate C^1 dovetail into the projections c^2 on the plate C^2, so that when the two plates are arranged side by side a pin or rod D can be passed through the projections to hold the plates together and form a hinge joint to join up the two ends into a continuous lattice. Two of the lags A on both sides of the end lags A^1, A^2 are also provided with similar metal plates C formed with tubular projections *c* arranged on the underside of the plates. Short pins *d* equal in length to the width of the plates are passed through the tubular projections *c* to hold them together. The plates C are affixed to the lags A by bolts passing through holes in the plates. (*Sealed.*)

MISCELLANEOUS.

194,360. A. J. Bailey, Salford, and F. M. Bailey, Salford. Thermostatic Valves. (7 *Figs.*) December 3, 1921.—The invention relates to thermostatic valves employed in connection with drying chambers. According to the invention, the thermostatic valve comprises two members 7, 14, one, 7, formed of metal

Fig. 1.



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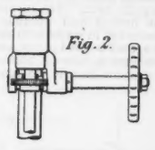
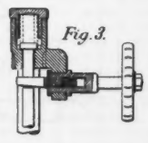


Fig. 3.



or material of low expansibility under the influence of heat and the other, 14, of high expansibility under the influence of heat. These members are connected together, the expansion and contraction of one of them being caused to open and close a valve. (*Sealed.*)

194,344. J. Davies, Liverpool. Icemaking Apparatus. (15 *Figs.*) July 14, 1922.—The invention relates to apparatus for making ice of that type in which the heat-exchanging units consist of a series of flat coil elements, and the refrigerant being directly expanded through the coil to freeze the water in the spaces between the coils into ice blocks. According to the invention, a flat coil or heat exchanging unit consists of lengths of rectangular section tubing 2 arranged side by side in abutment, the ends of

Fig. 1.

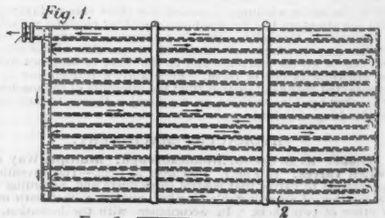
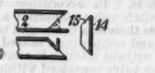


Fig. 2.



stretches of which are connected or bridged by short lengths 14 of straight or bent pipes or tubes of rectangular section, formed of tubes, pipes or channels mitred as at 15, or fitted to the contour of the edges of the open ends of the stretches, which ends are cut and bent in such a way that the whole of the joints may be subjected to exterior welding when the short pipes, tubes or channels 14 are in position, and so that all the outer surfaces of the short pipes or tubes are exposed. (*Sealed.*)